AD-A131 850 EUROPEAN SCIENTIFIC NOTES VOLUME 37 NUMBER 6(U) OFFICE 1/1
OF NAVAL RESEARCH LONDON (ENGLAND) D MOSHER ET AL.
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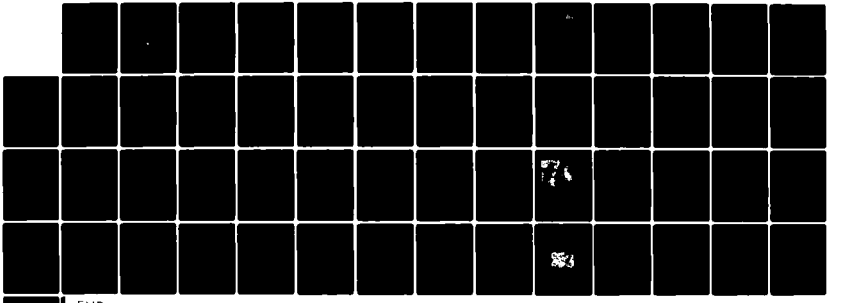

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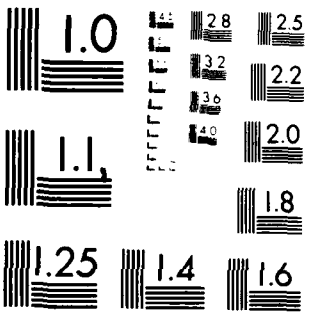

OFFICE OF NAVAL RESEARCH
LONDON

EUROPEAN SCIENTIFIC NOTES

ESN 37-6

30 JUNE 1983

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 37-6	2. GOVT ACCESSION NO. AD-A131 850	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EUROPEAN SCIENTIFIC NOTES		5. TYPE OF REPORT & PERIOD COVERED Monthly June
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) D. Mosher and Larry E. Shaffer, editors		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Office of Naval Research, Branch Office London Box 39 FPO NY 09510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 30 June 1983
		13. NUMBER OF PAGES 48
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

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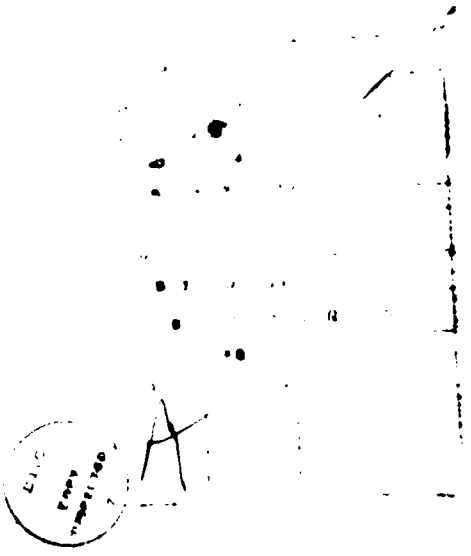

EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

Edited by David Mosher
Larry E. Shaffer

Vol 37, No. 6 30 June 1983

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ESN 37-6 (1983)

European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research, London, in accordance with NAVEXOS-P-35.

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BEHAVIORAL SCIENCES

ALCOHOL CONSUMPTION BY OFFSHORE OIL-RIG WORKERS

Many British oil-rig personnel are flown to the North Sea rigs by helicopter from Aberdeen, Scotland. A popular work schedule is 2 weeks on the rig, then 2 weeks of free time ashore. Aboard a producing rig, the work is often demanding and occasionally hazardous, and alcoholic beverages are strictly prohibited. Fairly adequate quarters and food and some recreational facilities are provided free to those aboard. Because oil workers are highly paid and "hit the beach" with money and some free time, considerable drinking on shore has been observed. A recent study tried to find out just how much alcohol was consumed; the investigators were G.J.M. Aiken and C. Lance of the Aberdeen Univ. Mental Health Research Unit.

The procedure was to administer questionnaires to all workers arriving at an "accommodation base" (preflight center) or at three production rigs in the East Shetland Basin. Because of bad weather and security or administrative delays, some of the men had already been offshore for a day or two, but most had just finished their shore vacation and were going back to work. The questionnaire asked the respondents to list every drink taken during the week just before they left for the oil field (a previous pilot study had shown that the subjects cooperated well and that the brief forms used were acceptable). The drink record was then reduced to 9-g alcohol "units," with each unit being equivalent to about half a pint of beer, a 1-ounce shot of 70-proof whiskey, or a glass of table wine. About 80% of the completed forms were suitable for analysis, for a final sample size of 213. The questionnaire had a few bio-data items to help specify the sample.

With an age range of 18 to 56, a mean of 33.4, and a standard deviation of 7.8, most of the workers were in their twenties and thirties. As seen in Figure 1, reported consumption was clearly skewed, with about one-sixth of the sample claiming total abstinence, and another sixth drinking over 80 units during the week. If the claims were accurate, then nearly half the sample had exceeded the safe drinking "upper limit" of 56 units per week suggested by the British Royal College of Psychiatrists. The mean for the entire oil-rig group was 49.3 units per week. The highest consumption reported was 233

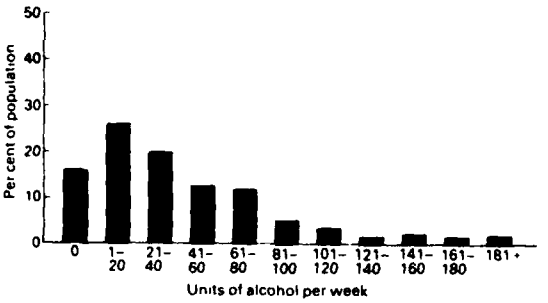

Figure 1. Consumption rates.

units, which amounts to more more than a quart of gin plus 4 pints of beer every day of the week.

Several biological variables were related to quantity consumed. Married workers apparently drank less than unmarried, and nonsmokers and executives also reported lower levels than did smokers and manual workers. When the manual workers are compared with shore-based manual workers in Scotland, the oil-rig people drink very much more. In fact, the average alcohol consumption of the petroleum workers was more than twice that of men in Scottish non-drink-producing industries and half again as much as that of employees of beer and whiskey companies.

Although all retrospective questionnaire data are suspect, research in other British and American projects shows that alcohol reporting is often an underestimate of actual consumption. At least one can say that all the indications point to heavy intermittent drinking by oil-rig workers. As Aiken and Lance observe, there are many unknowns about the effects of this kind of "alternating" drinking behavior on relatively high-status working men. To what extent does the 2 weeks of oil-rig "relief" from alcohol protect the liver, for example; and what happens when a worker on an alternating regimen of heavy drinking and abstinence returns to a "regular world" of work, with alcohol available every night? Despite oil booms in many places around the world, these questions have not yet been answered.

Oil-rig managers may already be aware that many workers who appear at the rig may be in a post-alcoholic state, which hinders effective work. There seem to be no reliable comparative data on job performance just after returning and on the different amounts of alcohol consumed ashore (since the questionnaires were anonymous, such follow-up could not be attempted). Even if data were available, the big question

remains: exactly what can be done about it? From a certain standpoint, the oil industry has established conditions of work that facilitate high consumption of alcohol. The 2-week shift system automatically produces a very abnormal family and social life; the paying of high wages just before the idleness of shore leave is, as mariners have known for centuries, an invitation to drunkenness. To justify his shore-based over-consumption, the drinking worker can always point to the isolation and the strenuous work he has just endured and will soon encounter again. The 2-week shift system, wages, and other conditions of work were developed in good faith by the oil industry, the unions, and the British regulatory authorities. But the official certifications of oil-rig work agreements raise grave and unsolved issues about the control and general health of workers. Nobody knows how to handle oil booms, or, indeed, just how to manage any working environments that are highly irregular.

Military managers will be struck the similarities between the situation on an oil rig and that prevailing in the armed services. In military life there is often the same kind of rigid alternation between strenuous work and idleness, the same sudden money, the same traditions of drinking bouts. Though military personnel are not so highly paid, there is also an economic factor: very inexpensive alcoholic beverages are available, and the cost is even less during "happy hours" at on-base clubs. Military celebrations almost always include alcohol, and model people, such as high-ranking officers, openly consume alcohol.

The picture is not hopeless, and many things can be done about heavy drinking by workers who are occasionally isolated. Some workers in the East Shetland Basin do not drink at all; others drink very moderately, and the social correlates of these behavioral tendencies are becoming better known all the time. As a famous US Air Force study showed a few years ago, dangerous behaviors such as drunken driving can be sharply reduced by: (1) public display of the consequences of drinking and driving (prompt public showing of offenders, with large color pictures of their crashed cars and victims), and (2) strong official and public ridicule of drunken driving as a sign of "machismo" or tough maleness. When the tragedy he caused is viewed in cold daylight, the drunk driver appears simply stupid, not a tough hombre. In the immediate future, perhaps some slow but steady gains will come through a detailed study of the "worker subculture," the reduction of social support for drinking bouts, and the provision of activities that will serve as attractive substitutes for the present patterns of drinking. Since the responses to such programs will differ from one individual to another, predicting responsiveness to change will be an important part of remediation management.

When anti-drinking programs are put in place for special groups like oil-rig workers or other "boomers," there probably will be some recommendations for the subjects to follow, some rationalistic model of treatment, and some kind of monitoring system for evaluating critical behaviors in the target population. The problem of *adherence* to the recommendations will then arise, which means there will be practical problems of predicting and maintaining adherence to or rejection of the regimen, as well as the scientific problem of understanding individual differences in adherence. Recent American research on helping relationships, notably from Irving Janis at Yale, indicates that some of the variables underlying effective client "progress" toward self-control can be specified. For instance, there are indications that *moderate* disclosure of information from client to counselor is better than either low disclosure or high disclosure. The Janis model of clinical progress through a respected counselor postulates a dozen variables that influence the referent power of a behavior-change agent. It would be interesting to see how many of these variables could be confirmed in modern boom town settings like the North Sea and Middle-Eastern oil fields.

In any case, techniques for prevention do not seem to be very effective. Official U.S. Congressional figures (Quayle, 1983) claim that about 10% of American junior high school students have drinking problems, and that 1 in 11 American high school seniors uses marijuana every day.

Reference

Quayle, D., "American Productivity: The Devastating Effect of Alcoholism and Drug Abuse," *American Psychologist*, 38 (April 1983), 454-458.

N.A. Bond, Jr.

COMPUTERIZED RECOGNITION OF PERSONS BY EEG PATTERNS

EEG patterns differ among individuals, and in many cases an expert human analyst can identify the pattern of a particular individual over time. Such a pattern often can be identified even when the person is experiencing various stimuli; this is true regardless of the particular recording setup used. It is also well known that uniovular twins exhibit quite similar EEG patterns. Such findings support the idea that EEG "individuality" might be defined rigorously, perhaps by means of computer-aided devices. Changes in a person's "basic" EEG tendencies might then be correlated with experimental treatments, with drug regimens, or with clinical progress.

The above possibilities have been investigated for the past several years at the University Psychiatric Clinic in Zurich, Switzerland. The approach of H.H. Stassen, R. Günter, and G. Bomben, the major investigators, had three major goals:

1. To obtain EEG data reliable enough for analysis, and to verify the processing techniques,
2. To explore long-term stability of specially "scored" individual EEG readings, and
3. To correlate key individual pattern features with patient events and clinical states.

Substantial progress on the first two of the objectives has been reported during the past year or two; the system for longitudinal analysis of EEG data at Zurich is now believed to be among the most advanced in Europe.

Anyone who looks at a long EEG record is impressed with the sheer amount of information. While some of the data can, upon inspection, be ascribed to "random" or transitory events, other portions can reasonably be presumed to reflect relatively stable conditions of the moment. To deal with the complexity, Stassen and his colleagues divided the data analysis problem into subproblems. A first or "pattern detection" set of algorithms was used to recognize the critical features in a continuous set of data. The Zurich approach was to use an adaptive scheme for selecting the "best" descriptors. Once there is a "best," or at least "good," description procedure, then a second requirement is to classify a new or unknown record into a set of previously defined classes. For this part of the problem, the Zurich group used the general logic of statistical decision theory, with special scoring schemes based on work in the automatic recognition of human speakers.

With a four-channel recording setup, recorded epochs of 20 seconds each were selected visually and were marked with a code for muscular and other artifacts. The spectra of consecutive epochs were scored for minimum and maximum power in each frequency. A spectral pattern was then a (C+1)-dimensional bounded volume, where C is the number of EEG parallel channels of information. With this approach, a one-channel pattern can be shown as a two-dimensional region bounded by the minimum and maximum distribution curves, and so on for any number of channels.

Any two patterns, say n and m, were then compared on the similarity measures, s,

$$s(n,m) = \frac{1}{r} \sum_{k=1}^{r} W_k \left[\frac{n \cap m}{n \cup m} \right]_k$$

where: r = number of frequency bands
W_k = weights
$[\ ]_k$ = normalized common volume restricted to the actual frequency band.

Free parameters were fitted by numerical methods to EEG data from over 100 individuals in a calibration sample. Among the results were the following:

1. An interval of 2 or 3 minutes of net EEG time was sufficient for estimating individual spectral variances.
2. The most discriminating bands were 0 to 7.5 Hz, 7.5 to 15 Hz, and 15 to 32 Hz.
3. If the "best" EEG channel was used, about 75% of maximum discrimination power was attained; for two and four EEG channels, the ability to discriminate among persons increases to 87% and 92% (test sample data entirely different from calibration data).

One surprising general result was that calibration weights were very much the same, regardless of which samples were taken; that finding suggested that the procedure would be robust across groups of people, and lent credence to the whole processing scheme.

Plotted functions for two records of the same individual taken at different times were often strikingly similar. Figure 1 shows two records taken 14 days apart from the same man. The extremely similar records are not exceptional, and

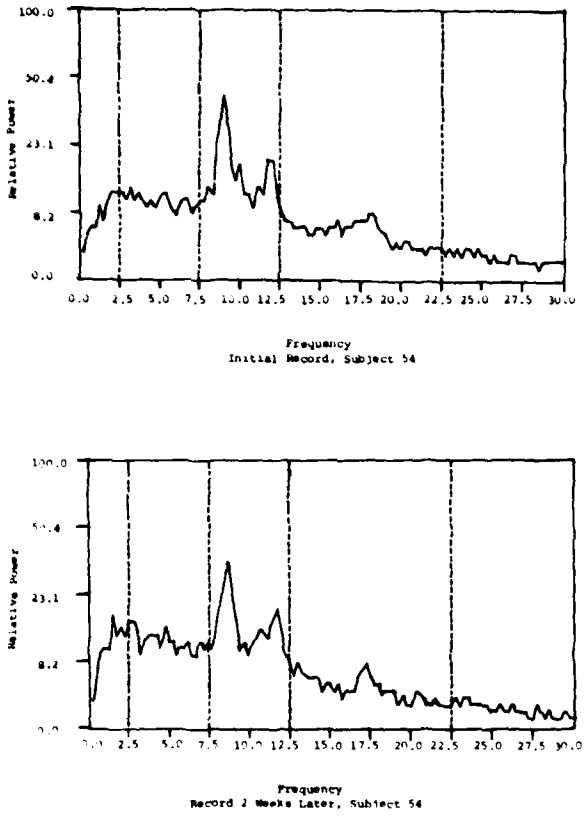

Figure 1. EEG spectral patterns (one channel) from the same individual separated by an interval of 14 days.

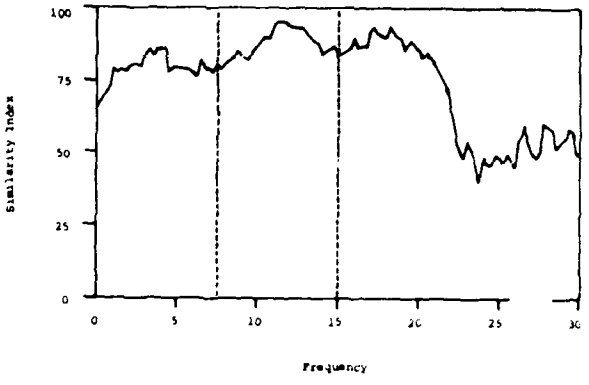

Figure 2. Similarity function for and right temporo-parietal EEG, individual, same time.

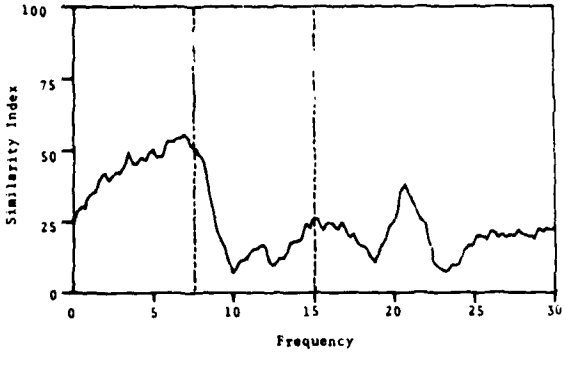

Figure 3. Inter-individual comparison of one EEG channel.

many pairs of processed spectra functions in the sample showed resemblances that were about like this example.

The similarity index s(n,m) was also computed between different simultaneous channels. Figure 2 depicts the similarity function for temporo-parietal EEGs of the left and right hemispheres of the same person. In this illustration, the weighted patterns had a high coincidence below frequencies of about 20 Hz, with a sharp fall-off at higher frequencies.

Stassen's procedures permit the informal "clustering" of subjects. The similarity graph in Figure 3 was computed from two different people; their patterns are quite different (similarity is low), except for a rather unusual "rising similarity" in the region below 8 Hz. In matched or clustered groupings of people, an investigator could check many classificatory or clinical conjectures rather quickly with the Zurich system. For multidimensional scaling of EEG data, Stassen also has developed special procedures that give a geometric interpretation of clusters and structures. The approach may eventually yield different EEG dimensions or factors as a function of experimental or

clinical states. It is already known that if subjects are given mild acoustic stimulation during EEG recording, the computed similarity among them decreases. Still, with Stassen's data transformations and indexes the ability to discriminate among subjects remains about the same across circumstances. This is a remarkable result, as discriminant function coefficients often vary with experimental conditions.

Stability of the specially transformed EEG records over time has been shown in 32 healthy "baseline" subjects. People in one of Stassen's samples were measured twice at an interval of 14 days and with 24 minutes of recording time for each subject. About 90% of the identifications were correct. A very small sample (six subjects) from this group has been followed up a year later, also with encouraging results--perfect identification. Very interesting applied research in EEG analysis should result from the apparent stability of the highly processed indices, and from the power of the Zurich system to separate EEGs into components that are either static (stable over time) or dynamic (dependent on conditions).

It remains to be seen whether the Zurich approach can illuminate further the "genetics of EEG." Certainly the stable component could be interpreted as being primarily genetic in origin. At the least, investigators who are interested in the genetics aspects probably will take into account the performance indexes that Stassen and his colleagues have so carefully developed and validated.

N.A. Pond, Jr.

SWITCHING TO LOW-TAR, LOW-NICOTINE CIGARETTES

Because of pressure from health authorities and other groups, tobacco manufacturers have been marketing cigarettes with lower tar and nicotine yields. Appreciable numbers of smokers in Europe and America switched to the presumably less harmful brands. But nobody knows just how much health benefit is realized by switching.

A cynical view of tobacco addiction is that such switching is futile: the smoker simply smokes more and inhales more, with negligible reduction in the intake of harmful components. Indeed, two British surveys found that regular smokers and low-tar, low-nicotine (LTLN) smokers had very similar blood nicotine and carboxyhemoglobin (COH_b) levels. But the LTLN smokers in the surveys were self-selected. What happens when users of regular cigarettes are switched experimentally to LTLN products--do they compensate immediately by smoking and inhaling more? And what are the medium-term use and health effects of the switch? Can switchers stick to the new low-yield product?

One of the few medium-term studies on "forced" switching has recently been reported by the Addiction Research Unit, Institute of Psychiatry, Denmark Hill, London. Among the investigators were M.A.H. Russell, S.R. Sutton, R. Iyer, C. Feyerabend, and C.J. Vesey. The unit's work with Nicorette chewing gum was described in *ESN* 35-12:441-443 (1981). More details about the study reviewed here can be found in the *British Journal of Addiction*, 77 (1982), 145-158, and in various technical reports of the Institute. (Incidentally, psychologists will remember the Institute as H.J. Eysenck's home laboratory.)

Russell and his colleagues at the Addiction Unit used newspaper advertisements to recruit smokers from the London area. For one group of 12 adult smokers (8 females), a follow-up study was designed, and each participant had to visit the unit over a period of 12 weeks. During weeks 1 and 3, participants smoked their usual brands; during week 2, they smoked a middle-tar, middle-nicotine product. The first three visits provided the baseline measurements, and blood samples were taken each time. One cigarette was smoked just after the subject arrived at the unit.

After week 3, all subjects were switched to an experimental LTLN cigarette manufactured in Britain. The new product was supplied in plain white packs of 20 and was sold to participants for 30% less than usual cigarette prices. (Subjects were also reimbursed for local travel to the unit.) Blood samples were taken at 2 days, 8 weeks, and 10 weeks after the switch. Subjects completed questionnaires in which they rated the new cigarettes for characteristics such as satisfaction and taste. On visit day, participants were to keep a record of the cigarettes they smoked until their appointment time. The subjects brought in a sample of butts, which the manufacturer measured for nicotine content. Upon arrival each subject smoked one LTLN cigarette immediately; video-tape observation permitted the estimation of "puffing behavior" with the new product (number of puffs, interval between puffs, time

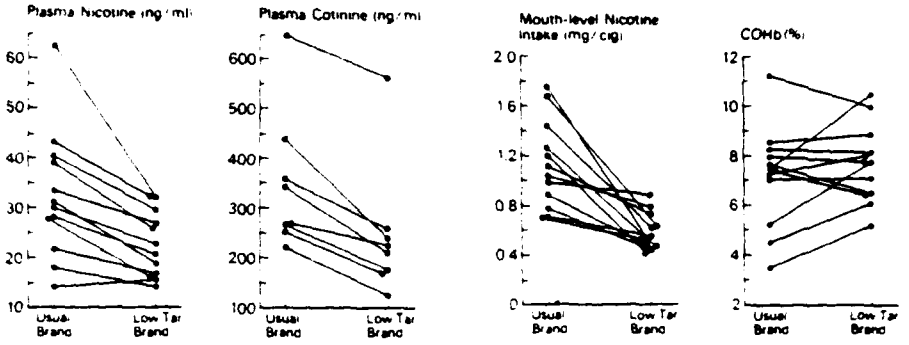

Figure 1. Measures of smoke intake when smoking usual brands and after switching to an LTLN cigarette for 8 to 10 weeks. Each point is the mean of two occasions.

to finish the cigarette, puff duration, and so on).

The Addiction Research Unit had previously developed methods for measuring plasma nicotine, plasma cotinine (a metabolite of nicotine), and mouth-level nicotine intake (derived from butt nicotine and estimates of filter effectiveness). In fact, the unit showed some years ago that it is even possible to estimate the CO absorption by nonsmokers in a smoke-polluted room, though the technique does not seem to be applied very frequently.

The key results were the blood chemistry and consumption figures after subjects smoked LTLN cigarettes for 8 to 10 weeks. Both plasma nicotine and plasma cotinine declined appreciably (about 30%) over the interval. Figure 1 shows the trends. Mouth-level nicotine intake dropped even more, over 40%. No overall change in COH_b percentage was observed.

Puffing and consumption figures were quite similar to the baseline measurements after the subjects had used the LTLN cigarettes for 8 or 10 weeks. The smokers averaged slightly more puffs per cigarette with the new product (about 17 compared with about 15 previously), but did not appear to be smoking any more cigarettes. Puff duration, puff rate, puff pressure, and puff volume were very much the same.

Subjectively, experimental cigarettes were quite acceptable to the subjects. While the cigarettes were rated "too weak," all subjects said that they felt they could change permanently to the new brand.

Smokers inhaled more frequently and deeply to compensate for the lower yields of tar and nicotine in the new cigarettes. The investigators determined the reductions in nicotine and cotinine output from machine-smoked new cigarettes and compared the results with blood-measurement reductions actually achieved by the smokers. The compensation (more smoking or inhalation) was quite incomplete, on the order of 36% of what would have been expected if the subjects had simply smoked enough additionally to produce their previous nicotine-cotinine intake. The inference is quite clear: smokers do not have a fixed nicotine level which they seek to maintain. Calculations for tar intake also indicate that compensation on that variable was incomplete, perhaps on the order of 50 or 60% of what "full" compensation would have been.

The maintenance of the same COH_b levels over the 8- to 10-week LTLN period indicates that members of the sample compensated fully for the reduced CO in each new cigarette. Addiction Unit investigators do not believe that a fixed CO level has thereby been demonstrated. After all, the new cigarettes had only a 24% (machine-smoked) reduction in CO yield, compared with a 47% reduction in nicotine yield. The best present guess is that some unidentified gas-phase component may be "addictive" and is correlated with CO but is not CO itself. Thus, an experimental question again seems to have a clear answer, at least for this small group: smokers switched to LTLN products do inhale more, but their overall intake of tar and nicotine is much less than it was previously.

The Addiction Unit's study has several positive implications. As just mentioned, smokers can significantly reduce their tar and nicotine intake and will not totally compensate for a weaker

product. It follows that pressure on manufacturers to reduce tar and nicotine should continue, and that people who smoke can reduce the health hazard by using LTLN products. Acceptability was adequate, and the subjects felt little sense of deprivation. The extent to which nicotine and tar levels can be reduced without making the product unacceptable should be studied experimentally, since it is known that smokers will not buy extremely low-level products.

Recruited participants and volunteers do not necessarily reflect the general smoking population, of course. It would be advantageous to know how the "project participation" experience and regular visits to an established institution contribute to the subjects' behavior and to their ratings of experimental tobacco products. Now that measurement methods have been well standardized by the Addiction Unit and other research groups, really large-scale switching experiments are being contemplated. Because even the most effective antismoking treatments (such as Nicorette gum) work with only about 40% of subjects, it is essential to develop programs that can improve the health of those who continue to smoke.

All the switched smokers reported that they had no trouble staying on the reduced cigarettes and expected to keep smoking them. Longer term follow-up studies now under way should address the obvious questions regarding the proportion of "backsliders" and "total quitters" in experimental smoker samples. The fact that compensation was only partial and remained steady after 8 or 10 weeks of LTLN smoking suggests that gradual but significant adaptation to reduced tar and nicotine load can be managed by ordinary smokers.

Health expectations for present tobacco users can be expected to improve gradually over the years. Special aids such as Nicorette and short behavioral-modification programs can reduce or eliminate smoking in a sizable minority of users. For a large fraction of persistent smokers, tar and nicotine content in cigarettes and pipes can be brought down without extraordinary interventions or demands on the addicted subject. Therefore, an attainable goal may be to reduce tobacco health hazards by some 40% or more over the next two decades. Cigarette use by adults is dropping slowly but steadily in many developed countries. But there are negative indications, too. At the moment, smoking in young people is not dropping in Britain and is increasing in France--and young smokers tend to use stronger tobacco products.

M.A. Bond, Jr.

BIOLOGICAL SCIENCES

TRACKING A SHARK BY SATELLITE

For some years, scientists have attached radio transmitters to animals for tracking them on land or in the water. Polar bears, sea turtles, and even birds are now routinely fitted with tracking devices. Usually there must be a specialized receiving system nearby, and it is difficult to monitor more than a few animals. Last year, I.G. Priede (Zoology Department, Univ. of Aberdeen, Scotland AB9 2TN) used the US Tiros N and NOAA 7 earth resources satellites to track a basking shark. The successful tracking gives a glimpse of what can be expected from the technology.

Priede took advantage of the ARGOS data collection system. Developed by both France and the US, the ARGOS package can receive messages from up to 4,000 ultrahigh frequency platform transmitter terminals (PTTs) and can receive from 230 terminals at any one time. With information gathered in a random data-sampling mode from both satellites, up to 28 location fixes per day at the poles and eight at the equator can be achieved for each PTT. The PTT messages from each source are 360 ms long, and the basic data are received in Toulouse, France, where Doppler calculations estimate locations. The fixes are usually accurate to within a kilometer or less.

The basking shark (*Cetorhinus maximus*) observed by Priede can be a very large fish; it can grow to some 10 m in length and can weigh up to 7 tons. In the summer, it feeds on plankton near the surface, and often can be seen off the Scottish coast. The PTT used in the shark application was ruggedized over a series of trials; early models could not stand the stresses caused by the shark's movements in the water (Figure 1). Because deep water would absorb the signal, the present device was fitted with a pressure switch which deactivated the transmitter when it was submerged. The PTT was attached to the shark while the fish was on the surface. Working from a small boat, the researchers used a hand

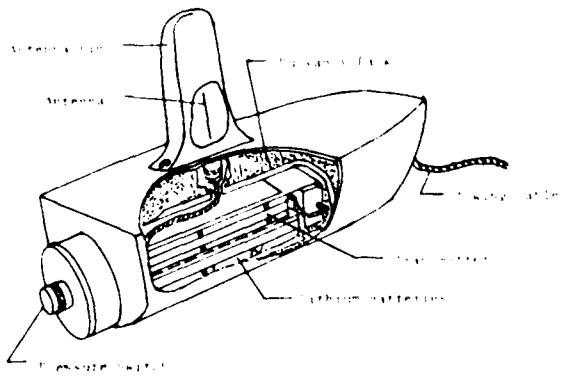

Figure 1. PTT package towed by sharks.

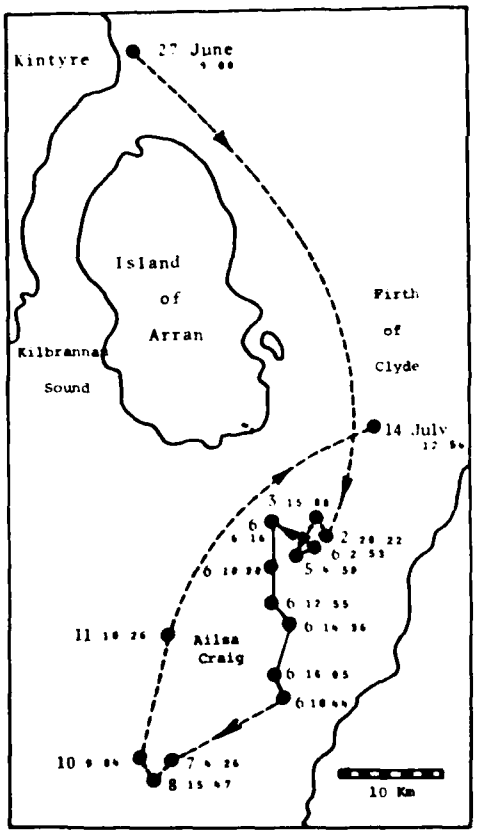

Figure 2. Shark track from 27 June to 14 July 1982.

harpoon to inject a barbed anchorage into the base of the shark's dorsal fin.

Two days after being fitted, Priede's subject disappeared for some days, presumably into deep water. The shark was located again some 55 km south of the original fitting.

The first successful tracking lasted 17 days; then the tow line broke, and the PTT floated ashore still transmitting (11 locations were recorded from the PTT during the free drift). Because the fish stayed close to the surface a large part of some days, good swimming patterns occasionally could be inferred. On 6 July 1982, for example, the seven fixes made the path of the fish quite evident as it swam down the Firth of Clyde (Figure 2). Straight-line swimming speeds on the order of 1 knot per hour can be deduced from the successive fixes.

With this tracking technology, other satellite information on water color and plankton indications could be correlated with fish movement, and such studies should lead to better models of the seasonal behavior of fish. The fish tracked here was apparently a "Clyde-side" Scottish resident for a large part of the summer, but its behavior in winter is uncertain. It is expected that smaller PTTs soon will be produced; they should make it feasible to obtain longer fish tracks with a variety of species.

J.A. Bond, CP.

CHEMISTRY

POLYMERS AS CONTROLLED-RELEASE AGENTS

The use of polymers to enable drugs, or for that matter any other chemicals, to be released slowly, in a controlled fashion, at a constant or modulated rate has become an active area of research. A 1-day meeting on the subject was held in London on March 23.

Sponsored by Macro-group U.K. and organized and chaired by Dr. M.B. Huglin (Univ. of Salford), the meeting featured six main lectures and two short research communications. Four of the lectures and both communications were concerned with medical applications; the other lectures dealt with agricultural uses of polymers and with the formulation of biocidal antifouling coatings.

Prof. N.B. Graham (Univ. of Strathclyde, Glasgow) reviewed current medical applications of polymers and discussed recent results from his own laboratory. The low diffusion constants for most molecules in high polymers make them ideal for slow release. Normally the release is proportional to the square root of time. But with constant reservoir membrane systems or with specially shaped devices, essentially linear release can be obtained. Special hydrogel and glassy polymers which swell can also lead to linear release with time.

In addition to these diffusion- or relaxation-controlled, polymer-based systems, bioerodible polymers are used. A new and extremely important development is the targeted release of drugs to specific sites of the body. Graham described a number of release systems already used for birth control and for treating asthma, colds, glaucoma, motion sickness, analgesia, and malaria. Work at Strathclyde employed crosslinked and semicrystalline polyurethanes as host polymers for prostaglandin. The drug eases and induces labor in childbirth and has been used successfully on 400 patients. Other structures in cylindrical form with blocked ends have been successfully used for the rectal delivery of drugs; zero time release of up to 12 hours has been achieved. Bioerodible "slabs" for the release of norethistrone as oral contraceptives are also being investigated.

Dr. P.L. Gould (Pfizer Co., Central Research Department, UK) discussed methods for following the rates of release and evaluating the effects of the drugs and devices. Gould's work concentrated on 100-day therapy; *in vitro* testing is done first, then *in vivo*. Finally, *in vitro* and *in vivo* results are correlated. A number of published methods were discussed, including automated systems. Fast results are needed in order to avoid the 100-day waiting period; speed is especially important for quality control.

Prof. S.S. Davis (Univ. of Nottingham) described the use of polymeric microspheres for drug targeting. They are intended to be injected intravenously for cancer therapy and must be biodegradable and nontoxic. Targeting can be done by varying the size of the microspheres. The larger ones enter the lungs, the smaller sizes--down to 100 nm--end up in the liver and spleen. Microspheres smaller than 100 nm enter tumors and bone marrow. Albumin, polylactic acid, and polyalkyl cyanoacrylates have been used. The effectiveness of the targeting process has been followed by incorporating gamma emitters such as iodine 131 and indium 111. Photon correlation spectroscopy of scattered laser light is used to measure the particle sizes. Davis also discussed the use of polymeric backbones with a "homing" device attached and with the drug attached to side chains--an approach developed by H. Ringsdorff (Univ. of Mainz, West Germany).

Dr. F.G. Hutchinson (ICI Pharmaceutical Division, Alderly Park) described work on biodegradable polymers for controlled drug release. With such systems the molecular weight of the drug is not rate determining as is the case with the diffusion devices. Combined diffusion-degradation systems can also be very useful. Hutchinson has used poly dl glycollic acid-lactic acid copolymers made by ring opening with, for example, stannous octoate as the catalyst. Blocky copolymers tended to be formed; these have different degradation rates than the random copolymers. Different ratios of each comonomer and the methods of synthesis yield a wide variety of release characteristics. As the molecular weight of the host polymer decreases by degradation, the rate of water uptake increases. This can lead to faster release rates, counteracting the normal square root loss with time.

Dr. D.J. Sloan (Univ. of Salford) described in a brief research communication his work conducted with M.B. Huglin on the release of ergotamine from crosslinked polyhydroxyethyl methacrylate. The drug is used to combat migraine, and its rate of release from films immersed in solutions buffered at pH 6.9 was followed by fluorescence analysis. Square root of time behavior was found with mean diffusion constants in the range of 10^{-13} cm^2/s. The composition contained tartaric acid to ensure solubilization.

The second research communication was presented by Prof. J.B. Lloyd (Univ. of Keele) and concerned the targeting, cell uptake, and intracellular processing of polymethacrylamide-oligopeptide drug analog conjugates. He was interested in pinocytosis, the engulfing of particles or fluids by cells--how, for example, do particles enter the cells and liposomes? Nitroaniline was used as the drug analog and attached to the polymer. The links were stable in blood but were degraded by the liposomes. Lloyd primarily studied polyhdroxy propyl methacrylamide. The amino acid sequences of the oligopolypeptides were found to be very important. Some were not digestible; others were, but at differing rates. Such systems were adaptable to targeting.

Dr. R.M. Wilkins (Univ. of Newcastle) discussed the use of lignin and other cheap agricultural by-products for attaching herbicides, such as carbetamide; plant growth regulators, such as cytokinnins; and insecticides such as the carbofurans. The objective is controlled release of the agricultural products; the substrates must be very inexpensive materials. In addition to lignin, researchers are studying polysaccharides, starch, chitin, various proteins, powered bark, sawdust, straw bagasse, coirs (from coconuts), and chaff. All contain many functional groups. At the moment, the cost is still too high, but Wilkins thinks that certain systems will be successful--for example, herbicides and insecticides for crops such as cereals, rice, and sugar beets. Weed control around the bases of newly planted saplings and the slow release of the hormonal herbicide 2,4-D (2,4 dichlorophenoxy acetic acid) for stimulating extra growth appear to have considerable potential in forestry.

Mr. A. Milne (International Paint Co., Newcastle) discussed the applications of slow release of biocides in antifouling coatings--mainly for marine applications. Zero-order release rates of 1 microgram/cm^2 per day for 2,000 days are needed, as are self-polishing coatings to reduce hydraulic drag. Vinyl carboxylate monomers with attached organic tin compounds were copolymerized and terpolymerized with other monomers to give very slow release. A thin layer of the polymer can be coated with another polymer layer. The specific products appear to be somewhat expensive but have excellent biocidal and self-polishing properties. These include practically unlimited lifetimes--depending on the amount initially applied--and antifouling and polishing rates that can be adjusted for different service conditions.

V.T. Stannett

UK RESEARCH ON LANGMUIR-BLODGETT FILMS, LIPOSOMES, AND BIOCOMPATIBLE SURFACES

The Royal Free Hospital School of Medicine of the Univ. of London has been concerned for some years with the study of the dynamic properties of biomembranes. Headed by Prof. Dennis Chapman (Department of Biochemistry and Chemistry), a group of researchers has introduced concepts such as biomembrane fluidity, phase transitions in biomembranes, and effects of cholesterol.

The scientists have also introduced various physical techniques for the study of biomembranes--e.g., calorimetry, infrared spectroscopy, nuclear magnetic resonance spectroscopy, and triplet probes for the study of biomembrane dynamics. Recently, the group has developed methods for polymerizing model and natural biomembranes. The present research program is concerned with liposomes, biocompatible surfaces, and Langmuir-Blodgett films.

Phospholipids that contain diacetylene groups in either one or both of the acyl chains have been synthesized. The phospholipids form multilayer structures when they are present in water above a certain critical phase transition temperature. Upon exposure to light or an electric glow discharge, extensive crosslinking to polymerization occurs so that polymerized liposomes are formed. They are being studied to see if they are useful as carriers for certain drugs and can act as drug delivery systems. The polymers produced in this way exhibit optical activity (Pons et al., 1982).

Enzymes or permeases can be included within the liposome structure. Upon polymerization, the proteins are trapped within the polymerized lipid matrix, producing immobilized membrane enzymes. The enzymes are tested for satisfactory functioning, and their technological potential is being assessed (Johnston et al., 1980). Sometimes it would be valuable to polymerize the biomembranes of whole cells, thereby locking into position all the glycoproteins, enzymes, and glycolipids. This has been done with *Acholeplasma laidlawii* cells. The microorganism has been grown in media containing synthesized diacetylene fatty acids. Biosynthetic incorporation of the fatty acid occurs with as much as 90% of the biomembrane material. Irradiation with ultraviolet light or an electric glow discharge produces extensive polymerization. The enzyme activity of intrinsic and extrinsic proteins was measured as a function of the extent of polymerization. Thus, one can obtain polymerized chips of whole cell material--chips retaining important biological and recognition characteristics (Leaver et al., 1983).

During his studies of biological membranes, Chapman noted that the outer polar surface of red blood cells differs from the polar groups on the inside surface. He reasoned that if a polymerized structure that contained the particular polar groups existing on the

outside surface could be created, he might be able to produce a new type of biocompatible surface mimicking the lipid polar surfaces of a biomembrane. Other cells and blood would then interface a "giant cell membrane surface," which should be nonimmunogenic and should have no tendency to increase blood coagulation processes.

Surfaces of the above type have been produced by preparing Langmuir-Blodgett films at an air-water interface in a film balance, consisting of a teflon trough measuring 18 cm by 45 cm and containing a pocket 4.2-cm deep at one end. Slides are passed through the sub-phase by a fully automated film lift. A feedback device keeps the surface pressure constant. By moving a teflon barrier coupled to a step motor, the device maintains a constant output of a pressure transducer connected to a Whilhelmy plate. The entire apparatus is enclosed in an acrylic case which can be purged with N_2. Temperatures can be regulated to 0.1°C using a circulating water bath. The apparatus can be coupled to a microcomputer to collect and store data and to control, for example, barrier speed or surface pressure. Pressure area curves can be determined. At a fixed pressure, the base material is raised and lowered through the lipid monolayer. Coatings are arranged so that the appropriate polar grouping (a phosphatidyl choline group) is on the outer layer. Polymerization stabilizes the layers. Coatings have been formed on various materials, including teflon, quartz, and steel.

Biocompatible coatings are being tested with intraocular eye implants and other prosthetic devices (Albrecht et al., 1982). Controlled polar surfaces are also being used for studies of cell adhesion and cell-cell contact.

Langmuir-Blodgett films prepared as described above are also being used to produce controlled surfaces of other specific polar groupings. Many electronic devices are made with such films, including metal-insulator-semiconductor diodes, electroluminescent cells, and field effect transistors. Chapman is exploring the Langmuir-Blodgett films for production of ion-selective electrodes and biosensors with improved biocompatible characteristics.

Other studies being carried out in his laboratory include: (1) the application of infrared difference spectroscopy for the study of biomembrane structure and protein-lipid interactions, and (2) the application of laser flash photolysis to the study of protein rotational diffusion in various biomembranes, including muscle and retinal membranes.

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V.T. Stannett

COMPUTER SCIENCES

CITROEN EVALUATES ROBOTS FOR ARC WELDING

The French automaker Citroen has been systematially evaluating the use of robots for arc welding. The company now has automatic machines that perform welds of 50 to 600 mm, often with several welding torches; a welding speed of 600 to 800 mm/min has been achieved. Specifically, Citroen is analyzing the possibility of using robots on automated lines to make short weld stripes.

Simulation of Actual Work

To test the performance of welding robots, actual work is simulated. One trial determined the position and number of points needed to complete a particular weld stripe. The parameters tested were speed of movement, load on the robot's wrist, and variation of steps in the program. Another simulation trial determined the precision of the robot at the start and stop points in the weld stripe. The parameters tested were maximum speed of movement, wrist load, and complexity of trajectory for the model. The test lasted 16 hours. A third trial checked the machine's precision--the extent to which the robot stayed within certain tolerances in producing the weld stripe. The parameters tested were speed of movement, wrist load, and trajectory accuracy.

The objectives of the trials were: (1) to determine costs and the relationship between price and performance for each of several robots on the market, and (2) to assess the robots' adaptability to the work to be performed.

Adaptation of Welding Equipment

Several pieces of equipment were adapted to the robot to determine the best performance; Citroen evaluated transistorized generators, reels of different sizes, torches of thermic efficiency, arrangements for the best winding to give the lightest work load for the robot wrist, automatic cleaning of the torch, flexibility in adapting the torch to the wrist, and a reel of wire of 200-kg weight.

Some trials were carried out with the equipment to test the arc in action, including the penetration of the stripe as a function of the rhythm of the arc and speed of the welding.

Application of Arc Robots in Production

Before the introduction of the GSA (1983 model Citroen), two robots per unit were used to deposit a stripe of 195 mm, including straight line and corners. Eighteen seconds were required for the welding and 28 seconds for other movements. Some supplemental weld stripes were put on export vehicles. Robots were tested for the job, which had previously been done manually.

For welding on rear axles, the issue at first was to see whether a robot or a special machine worked better; the costs of the two devices were similar. The production line, designed to be used with two different vehicles, was to be updated when the second was launched in 1983. A four-torch special machine had been chosen for preparing support of the "compensateur" (a load sensing brake appropriating valve) and the gas tank. Two linear stripes and two circular weld stripes staggered by 10 degrees were required.

Welding took longer with the robot than with the special machine; the other movement took the same amount of time. However, based on experience acquired over 18 months, it was determined that the total time could be shortened by moving the robot faster and improving the path of movement of the torch. Overall, the robot proved to be the better choice.

For welding a small cup on the "chistera" (a frame member of the rear axle beam), Citroen used a turntable with two torches at each of the welding positions. The circular weld stripes were 250 mm in circumference. When a robot was used, the results were estimated to be slightly inferior to the special machine.

Operation 10 is the term Citroen uses for a mechanical assembly that includes the introduction of parts and the welding of chisteras on a pipe. The robot made two linear stripes (2 × 60 mm) and performed four spot weld operations to assure the geometry of the axle. The time for welding was 16.2 seconds, and for other movements 19.8 seconds. When the all-robot approach to making four circular weld stripes was examined, it was clear that the welding took too long and that one robot per torch was required. For the special machine version to replace the robot and its movement, a six-torch machine including two movable torches was required. The price was higher, and the machine was more complicated to maintain.

Operation 20, the welding of traverse plates and abutments, is a mechanical assembly like operation 10. Operation 20 includes the introduction of parts and the welding of anchoring plates and abutments. The robot welded 150 mm of stripe and four spots. The welding time was 12.9 seconds; other movements took 24.3 seconds. For the specific machine version, it was necessary to use two machines--one for the traverse plate with two stripes and four spot welds, and one for the abutment with two linear stripes. As with operation 10, the machine version was more expensive and more complicated to maintain.

In operation 40--attaching the "chisteras" to the pipe--the special machine version required four torches for two stripes of 30 mm and two stripes of 90 mm. The assembly included the transfer and attachment of studs on the axle. For operation 40, more than one robot was needed to make the four stripes; the investment was 30% higher than for the special machine version. Subsequently, however, the 30-mm stripes were eliminated, making the robot version feasible.

The job of finishing the axle, operation 70, required the welding of a flexible foot and a reinforcing support. The robot welded two stripes of 10 and 15 mm and four stripes of 45 mm. The welding time was 17.4 seconds, and other movements took 21.6 seconds. The special machine version was eliminated because its welding costs were similar to the robot's, and another machine would be needed to change to the next vehicle.

Conclusion

The robots were selected because of their much greater flexibility. During the start-up period, the angle and distance of the torches can be easily changed. In one such operation, the time was reduced from 21.6 to 16.2 seconds. The movement time between welds also can

be decreased and the welding time improved to obtain the desired cycle time. A robot's flexibility is useful when changing the position or the length of the weld stripes to accommodate changes in the form or position of assembly parts. Robots, which are easily integrated on a conveyor line, are advantageous because the gripping equipment moves rather than a part or a torch. The robots are easily accessible for maintenance and service. On the other hand, special machines with several torches are heavily equipped and often difficult to service.

One of the weaknesses of robots is that breakdowns are costly. And when the stripes are all linear or all circular a special machine, unlike a robot, can handle simultaneous welding. Finally, when a robot is to make many stripes in the same zone, preliminary trials are needed to prevent deformation and to determine the best order of welding. Thus, nonwelding movement time can increase.

J.F. Blackburn

USE OF INDUSTRIAL ROBOTS AT VOLKSWAGEN

Volkswagen has become a sophisticated user and producer of industrial robots over the past decade. The need for robots in Volkswagen's plants became apparent in the early 1970s, when the number of models and styles of automobiles began to increase dramatically. Until 1973, when the Passat and Golf models were introduced, production consisted mainly of the VW Beetle, of which 18 million units had been built. Between 1976 (when the last Beetle produced in Germany left the plant) and 1980, 30 different types and styles of bodies became available.

In 1970 Volkswagen began assembling chassis with the Unimate robot. Production planners then began to think about developing their own robots to meet eight specific production requirements. The goal was for the robots to be versatile, to be easy to program, to be constructed of modular units, to have a simple design with substantial rigidity, to be adaptable for installation in any position, to have simple components requiring little maintenance, to be positioned within ±1 mm of a target, and to have a load capacity of 15 to 100 kg.

Based on these requirements, Volkswagen developed six types of robots. The first was the Articulated Arm Type K15, with a maximum of five axes (degrees of freedom). It is point-to-point controlled and is used for stacking and palletizing. The kinematics of its bending arm allows an operating area sweep from 2.8 m above to 0.5 m below the machine's mounting.

The Tubular Type R30 is equipped with six axes and can carry out in a small space all movements needed in the production process. The three wrist pivots allow the use of a gripper mounting, spot welding pincers, or similar tools. The unit is modular and can be reduced in size and function by deletion of one or more wrist axes or the linear axes.

The Linear Type L15 with three axes was designed to move parts. It has a fast moving linear arm (1.2 m/s) that can quickly cover relatively long distances. Several alternatives are possible for the gripper attachment to the linear arm. For example, the gripper can be mounted at one or both ends and can move with rotary or vertical swivel action.

The Tubular Type R100 is equipped with five axes, including one for lateral travel. It has a lateral travel range of 2 m and a load capacity of 100 kg. The robot is used for extremely large spot welding pincers and for handling heavy material.

The Joint Arm Types G10 and G60 can be continuous path controlled--unlike the other four robots, which are point-to-point controlled. The G10 was built for all kinds of material handling. It is small, requiring only 0.5 m^2 floor space, and this allows easy integration into existing manufacturing systems. It has six axes that are continuous path controlled and a seventh that is point-to-point controlled. The latter is a traversing unit supplement. The robot's repeatability accuracy is ±0.15 mm. The Joint Arm Type G60, a larger version of the G10, has more reach and higher load capacity--60 kg compared with 10 kg for the G10.

About 950 robots are now used in Volkswagen's plants, and the company plans to have 2,000 by 1990. About 65% of the robots are used for spot welding, 19% for material handling, 10% for gluing, 2.5% for mounting and assembly, 1% for arc welding, and 2.5% for miscellaneous tasks.

The work of robots that carry out spot welding operations is complemented by about 200 driverless transport systems, which automatically supply the robot processing stations with parts. Each of the systems, or carriers, has its own computer and is equipped with two drive units and two steering motors.

Aerials at the front and rear of the carriers sense the magnetic field of an induction loop imbedded in the floor and thus follow a path set by the direction control system. In conjunction with the carrier's computer, the control system automatically directs the carrier to the next free processing station, where the robot begins its programmed job sequence. Once the welding operations have been completed, the carrier moves on to the next welding station or to the unloading point.

For the side panel production of the Volkswagen Passat, 18 carriers are used on the transport system course. Each transport vehicle has its own computer and is equipped with apparatus for holding parts and components, which are supplied and unloaded automatically. A direction control system monitors data communication among the six processing stations, each of which has four spot-welding robots. For five model variants, the production line turns out 1,100 left and 1,100 right side panels in two shifts per day. The cycle time per vehicle is 105 seconds.

The production line for the body shell of the Derby/Polo is similar to that for the Passat side panel. However, the direction control system allows the carriers to drive sideways, saving space. The system communicates with the computers on the transport vehicles through a programmable control using information points, identification points, and information loops. The body shell line, which went into service in August 1981, has produced more than 205,000 units. The cycle time is between 70 and 110 seconds, depending on shell type. The circuit has 15 welding stations with 54 industrial robots supplied by 30 transport system vehicles.

The microcomputers used for robot control are Texas Instruments TMS9995 16-bit microprocessors, which work in conjunction with Advanced Arithmetic Processing systems. The manual control unit "teach" system is used for programming; an operator pushes buttons that are used to move the axes at three speeds. When the proper point is reached in space, its coordinates are stored in memory; thus, the robot is "taught" where to move. Programs permit variable speed selection; up to 15 relay outputs and 15 inputs, 15 programs, and seven gripper functions; palletizing; subprogram techniques; and variable timer function up to 10 seconds.

Volkswagen is now working on sensor techniques. A TV camera has been fitted to a Volkswagen industrial robot for tasks requiring recognition of positions and production parts. With this system, robots can recognize objects; measure distances, areas, and speeds visually; and determine the coordinates of objects in relation to a fixed position.

Although the system is not yet good enough for production use, a visual sensor is being developed for part recognition in pallets. The sensor will probably go into use later this year. In addition, point-to-point control will be replaced more and more with continuous path control.

Volkswagen now produces 10 robots per week, a rate that exceeds the company's requirement of 2,000 robots by 1990. With this excess capacity, Volkswagen probably will become an important supplier of robots to other companies over the next few years.

J.F. Blackburn

EDUCATION

COMPUTER AIDED INSTRUCTION

Computers are being used in education in a variety of ways and for a variety of reasons. Apple Computer's offer to give computers to every high school in California (and later to every one of the nation's 100,000 schools) made headlines a few months ago; Drexel Univ. has announced it will require each of next year's 1,650 entering freshmen to purchase a microcomputer (Apple's "MacIntosh" machine). And Commodore's policy of giving educational institutions a free microcomputer with every two purchased has received wide publicity. Governments in several European countries have also taken steps to place computers in elementary and secondary schools.

British educators think the UK is ahead of other countries, including the US, in introducing microcomputers into schools. In the past 3 years, the Department of Education and Science in the UK has spent about $13 million in its Microelectronics Education Program, and another $8 million has been budgeted for a 2-year extension. The UK's Department of Industry has also been in on the act with its $6 million Micros in Schools program, which provided funds to secondary schools to pay half the cost of purchasing certain microcomputers. Over 90% of the 7,000 eligible schools took advantage of the government's offer. Most of the schools purchased either the Research Machines 380Z

microcomputer or the Acorn BBC microcomputer. The government followed this with a similar program for the nation's 27,000 elementary schools. The condition for support was that the schools purchase one of three "approved" microcomputers--the 380Z, the Acorn, or Sinclair's Spectrum computer, all made in the UK. It has been reported that the BBC machine is the most popular choice among elementary schools.

The Department of Education and Science in the UK has provided substantial support for development of computer programs, or "courseware," for computer aided instruction, as well as training programs in computers for teachers. Spokesmen for the department have stated that special courses have trained 50,000 teachers in the UK how to use computers.

During the 1970s, France undertook a national program to provide schools with some help in acquiring access to computers, primarily through terminals with connections to "central" minicomputers. But the main emphasis was on teacher training, with programs ranging from 1-year, full-time institutes to correspondence courses. The French equivalent of Britain's Micros in Schools program is called Operation 10,000 Micros. Its aim is to equip every secondary school in France with eight French microcomputers. France also has continued with a variety of programs giving teachers computer training, and with projects for developing courseware. France has spent the equivalent of about $14 million on equipment and training and another $2 million for the development of courseware.

In elementary and secondary schools worldwide, computers are being used for administrative and secretarial chores (with business and word processing software); laboratory work; demonstrations presented to groups of students (such as simulations); individual student interaction with educational software; student programming; student exercises with word processors; and computer aided instruction schemes (some involving interaction with video disk players, voice synthesizers, or graphics plotters). Teachers also can use the machines for administering tests and keeping class records (called computer managed instruction).

Unfortunately, some microcomputers sit, unused, in the corners of classrooms; one reason is the lack of good software. The amounts spent on developing educational software are far outstripped by expenditures on hardware. There is a tendency, especially by administrators not themselves familiar with computers, to concentrate on acquiring machines, and computer vendors are only too happy to comply. Lack of knowledge about computers and their uses in education is a second serious problem. To a great extent, computers are arriving in the schools not at the request of the education community, but rather because of demands by the general public. Thus, educators often find themselves virtually forced to become involved with computers--to many, an onerous task. Those involved in mathematics education in the 1960s might perceive a parallel with the introduction of the "new math" into the primary and secondary schools. It is worth noting that the "new math" curricula failed essentially because they were not properly supported by teachers who were forced to use them. (It is also true that, unlike the computer situation, they did not enjoy popular public support.)

In a recent conference, "Computer Aided Learning" (CAL), held at the Univ. of Bristol, UK, use of computers in education and training was discussed. This was the second CAL conference; the first was held at the Univ. of Leeds in 1981, and the third is planned for Nottingham in 1985. In addition to over 50 papers presented in parallel sessions, the conference featured workshops in specific problem areas and formal demonstrations of software and hardware products. About 40 commercial and private exhibitors displayed educational products. There were more than 400 participants at the conference.

Some of the most impressive demonstrations involved coupling microcomputers with video cassette recorders (VCRs) or video disk players so that the video display is controlled under software running in the microcomputer. This allows interactive viewing by the student, testing of his comprehension, and presentation of review, remedial, or new material, as determined by diagnostics on the student's responses. The VCR is much less expensive than a video disk unit, but does not enjoy the latter's random access capabilities. Prof. D. Laurillard (Open Univ., UK) demonstrated a relatively low cost setup involving a VCR. The student could select among various options, such as playing straight through the video program, interrupting the video and going forward or backward to another section, or interrupting the video and selecting from a list of CAL programs. The video program was designed to teach several concepts, such as frequencies, harmonics, and digital wave forms, and

the CAL materials provided simulations and tests of the concepts.

A more elaborate system, involving use of a video disk unit, was demonstrated by Prof. F. Gastkemper (Univ. of Nijmegen, the Netherlands). The courseware was designed for use by third-year psychology majors and concerned observation of human behavior. Brief video sequences of simulated behavior by subjects were followed by multiple choice questions about psychological aspects of the behavior. Depending on the student's responses to the questions, selected frames of the sequence were displayed, together with brief textual explanations of the correct and incorrect answers. Gastkemper reported that the approach has been effective and is popular with the students. A similar video disk setup was demonstrated by Prof. R. Fuller (Univ. of Nebraska and the Open Univ., UK). The material was designed to teach students about standing waves; it effectively illustrated the concepts with moving pictures of the Tacoma Narrows bridge collapse and video sequences showing laboratory demonstrations and computer graphics.

Several papers concerned methods of developing courseware. Mr. K. Tait (the Univ. of Leeds, UK) presented a paper titled "The Building of a Computer Based Teaching System," in which he described three developments that are significantly influencing the growth of CAL: authoring languages; general-purpose, high-level programming languages; and easily available computing hardware. Authoring languages, such as Coursewriter, TUTOR, and PILOT, are themselves software systems that help educators write courseware. According to Tait, educators' use of "easy to learn" authoring languages has not resulted in quality interactive teaching programs; the programs tend to be "idiosyncratic and somewhat unreliable." On the other hand, Tait says, courseware produced by professional programmers is not often in accord with reasonable educational goals and methods. Tait described an authoring language he has helped develop--GALTS, for Generated Author Language Teaching System. Unfortunately, "even with the aids provided by GALTS, the writing of computer-based teaching material in the tutorial style is not easy," he said.

Several papers reported results of using CAL in engineering courses. Mr. P. Tinson (Queen Mary College, UK) presented a paper, "CAL in Nuclear Engineering," in which he described development of a set of about 20 nuclear engineering packages during the past decade at Queen Mary College. The object of each package is to supplement the lectures in much the same way practical work does. In the college's engineering courses, CAL is used to accompany laboratory experiments, to illustrate numerical methods, to provide a design exercise in which the student can vary components until design criteria are met, and to offer a computer "experiment." For such an experiment, the computer models a system which might not be feasible to deal with directly because of cost, hazard, or time requirements.

In spite of the euphoria about CAL exhibited at the meeting, it is clear that significant problems remain. Not much really good CAL software has been produced; it is expensive to develop (a video-disk-based training setup may cost over $1 million). Teachers have not been able to write good courseware because of lack of training and resources. There is "sales resistance" among educators, many consider the present move to CAL a fad. Results of development and use of CAL courseware have been reported for the most part by enthusiasts; rank and file teachers often are skeptical. However, using computers in education has the advantage of allowing individualized, interactive instruction; and some experts maintain that computers will become the dominant tool for educators in the next 20 years. Indeed, Prof. A. Bork (Univ. of California at Irvine) said he believes implementation of computers in education will have an impact comparable to that of the printing press.

D.E. Barr

ELECTRONICS

DELFT UNIV. OF TECHNOLOGY EXCELS IN PRECISION MEASURING TECHNIQUES

The Electrical Engineering (EE) Department at Delft Univ. of Technology (DUT) is modernizing its curricula and instituting a doctoral program. Research in the department emphasizes solid state materials, devices, and systems technology. Outstanding work is being done in precision transducer technology.

DUT is one of three technical institutes in the Netherlands, and with an enrollment of 10,000 students, it is the largest. Until recently, virtually all matriculations were at the master's degree level--a trend also reflected in

professional employment; 96% of all Dutch electronic engineers hold the degree as their highest level of academic achievement. A large fraction of the graduates have been power-engineering oriented, but there is now increasing interest in microelectronics.

Prof. Simon Middlehoek is internationally known for pioneering work on the wall effect in magnetic thin films and for being the first to investigate field effect transistors using control gates of sub-micrometer dimensions. While at the IBM Zurich research facility, he became familiar with many American approaches to research and education. Thus, it is not surprising that after joining DUT's EE faculty he was instrumental in reorganizing the research programs at the technical universities in the Netherlands.

Engineering Programs

Previously, engineering departments had received 200,000 guilders (about $74,000) each year to use at their discretion for equipment, but there was virtually no other support. As a result, there were few opportunities (or incentives) for creative graduate research programs. The situation is changing; government funding is now proportional to the number of publications of any scholastic department. In addition, the government now encourages the submission of research proposals.

DUT has benefited from the new policies, receiving 2 million guilders (about $755,000) to purchase an Electromask facility capable of lithographic resolution to 0.75 micrometers. In addition, DUT will receive 600,000 guilders per year to operate the facility. Semiconductor work at DUT has concentrated on bipolar technology as a sister university at Twente is the lead school for N-channel metal oxide semiconductor (N-MOS) technology. DUT currently is awaiting an answer from the Dutch National Science Foundation regarding their 30 million guilder ($11.3 million) proposal for a "silicon foundry" facility capable of designing, fabricating, and testing very large scale integrated (VLSI) circuits, including complementary MOS (C-MOS) microcomputers. If successful, DUT will join the Univ. of Edinburgh (see *ESN* 36-12:331 [1982]), the Univ. of Leuven in Belgium, and the Univ. of Aachen and Dortmund Univ. in Germany as European academic centers that have announced plans for such advanced capability.

Work on the fabrication facility will include software design, research, and development. Over 1,000 British software engineers are now employed in the Netherlands to compensate for the comparatively few Dutch software graduates. With thorough planning, such as that for the DUT C-MOS microcomputer facility, the Dutch seek to increase the number of technology-oriented PhD graduates from a few per year to 4,000 per year. North Sea oil and gas revenues are a major source of funds to underwrite the expansion.

The DUT electrical engineering department is organized into five fields: power engineering, information theory, telecommunications, computer sciences, and microelectronics. To reduce duplication of effort among Dutch universities, the high voltage engineering laboratory at DUT will be closed, leaving all such research to the Univ. of Eindhoven. As a result, power engineering at DUT will be reduced in scale, and microelectronics is expected to be given greater emphasis.

Within the microelectronics group are five branches: digital, analog, computer aided design (CAD), materials, and instrumentation. The branches cooperate in selected research projects; the group has worked on high speed junction charge coupled devices (CCDs) and has become internationally recognized as a center of excellence in precision transducer technology.

High speed junction CCDs offer advantages over the more common MOS-CCDs--e.g., excellent light sensitivity, good antiblooming properties, absence of fatal breakdown, and compatibility of same-chip bipolar transistor circuitry. The absence of metallic gates in the high speed devices is especially important for use in blue light sensing applications such as high resolution (i.e., high speed) color television work. Speeds up to 50 MHz have already been achieved with high speed CCDs, and on-chip logic is being investigated. The outstanding antiblooming characteristics of the device are obtained by virtue of the p-gates above the individual pixel potential wells; the p-gates draw off any excess charge carriers that may be generated by excessive incident light. Figure 1 depicts the basic structure. Current work is directed toward reducing leakage currents and thus improving effective transfer efficiency and reducing current load in the 3-Ø clock circuit.

Precision Transducer Technology

An instrument that possesses an inherent zero offset voltage and that never needs calibration is a dream of instrument manufacturers and field engineers alike. With a four-quadrant, silicon, bipolar transistor configured

as a magnetic field vector sensor, Middlehoek and one of his students, V. Zieren, have provided the basis for such an instrument. Figure 2 a plan view of the device. The emitter structure is n-type, centered, and 20-μm diameter. The base (not shown) is p-type, of 20 kΩ/□, 0.6-μm thick and 80-μm diameter. The pie-shaped collectors are n-type, have 0.85 Ω-cm resistivity, and are 9.5 μm thick. Hall mobility in the depleted collector regions is 1,400 cm²/Vs. In the absence of any magnetic field B, the electrons injected through the base region (by the centrally located overlying emitter) will be collected equally among the four underlying collector regions. The presence of a magnetic field B in the plane of the device (i.e., parallel to the surface) will create a Lorentz force on the electrons. The force is also in the plane of the device and causes an unequal collection of electrons among the four collectors. Each diagonally opposite collector section is fed to a common operational amplifier to measure the difference current. The outputs of two such amplifiers are compared. The resulting signal is found to be a linear function of magnetic field direction. When the collectors are connected to the op amps in a logic configuration for angle measurement, the transducer is independent of magnetic field intensity. A combination of measurements allows one to measure direction and magnitude simultaneously. Sensitivity is 4 millitesla and can be improved by decreasing the diameter of the emitter.

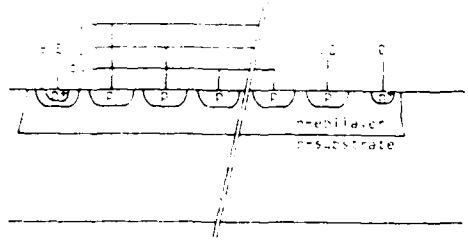

Figure 1. Structure of the high speed CCD.

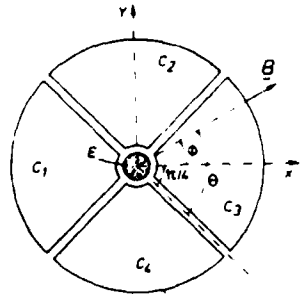

Figure 2. Precision transducer.

Because the Hall generator operates only with the magnetic field component perpendicular to the device surface, the combination of the DUT magnetic vector sensor and a Hall generator on a common planar silicon chip may provide a basis for a low cost, three dimensional, magnetic vector sensor. Such a device would eliminate the need to place separate magnetic sensors on each of three orthogonal faces of a precision machined cube.

Using two interdigitated arrays similar to those in surface acoustic wave transducer devices, but of 3-Ø instead of 2-Ø design, DUT designed and characterized an ultra-precision linear translational transducer. The two arrays are parallel and separated by a fixed distance. One array is fixed in position, while the other is given one degree of freedom to translate along the direction of the array length. The translation causes a variation in the capacitance between the two arrays, which can be measured as a variation in the 3-Ø excitation current. Remarkable precision is claimed; displacements as small as 22 nm (e.g., an ultraviolet light wavelength) can be measured. As temperature variations affect the fixed and moveable arrays in a similar manner, the transducer is remarkably immune to temperature changes. Although the device built was only 7.2 mm long, the technology can be used to measure a 110-dB dynamic range.

The most commonly used humidistat is based on the change of length of a horse hair (or synthetic material of similar characteristics) as a function of its moisture content. Such sensors are not noted for their precision and accuracy; moreover they require still other transducers, or analog-to-digital converters, or both, to be compatible with microprocessor-based systems. Using the interdigitated capacitive array described above, Middlehoek and his students found that the capacitance of one such array in ambient air changes very abruptly at the dew point. Thus the dew point can be determined accurately. If the sensing array and a temperature sensing chip are mounted on

a Peltier or other controllable cooling element, then the temperature of the apparatus can be lowered until water vapor begins to condense and cause an abrupt change of capacitance. The temperature at which the nonlinear capacitance effects occur is maintained by a control circuit; this temperature is an accurate measure of relative humidity. Sensitivity of 0.1°K over a 27-dB dynamic range has been demonstrated. Other applications of dew point sensing by capacitive techniques include refrigeration and heat pump systems, in which excessive frost build-up on evaporator coils may damage the equipment.

Inclinometry is another application of the 3-Ø precision capacitance measurement technique. In the DUT apparatus, mercury partially fills a U tube that has a 3-Ø interdigitated array plated on the exterior. The glass walls of the U tube act as the dielectric of fixed thickness, and the capacitance varies as a function of the area of overlap between the mercury and the array. To avoid hysteresis, a wetting agent between the mercury and the glass walls is necessary.

The above precision measurement techniques are of the proximity type. Remote or contact-free measurement of spatial coordinates to a high degree of precision are also important in many control applications. For example, VLSI circuitry requires precision control of the X-Y coordinates of the wafer during lithographic step and repeat processes. Other applications include attitude control in space, proximity, switching, and even gait control of people trying to walk during physical therapy.

D.J.W. Noorlag recently completed a doctoral thesis on research that used the lateral photoeffect to create a position-sensitive detector (PSD). Unlike other optical PSDs using one-dimensional arrays of detector cells, Noorlag's PSD is neither resolution-limited by cell size nor dynamic-range limited by cell numbers. The sensor is basically a large reverse-biased semiconductor p-n junction (Figure 3). The top p-region sheet forms a shallow tub-like structure in the underlying n-region sheet. Ohmic strip contacts are applied along two opposite edges of the p region. On the two opposite edges, the n region is exposed and ohmic strip contacts are attached. The overall p-n junction acts as a photovoltaic (solar) cell. If light is incident, a voltage is generated between the p and n contacts. If the light beam is but a small spot, however, electron-hole pairs are generated only in the

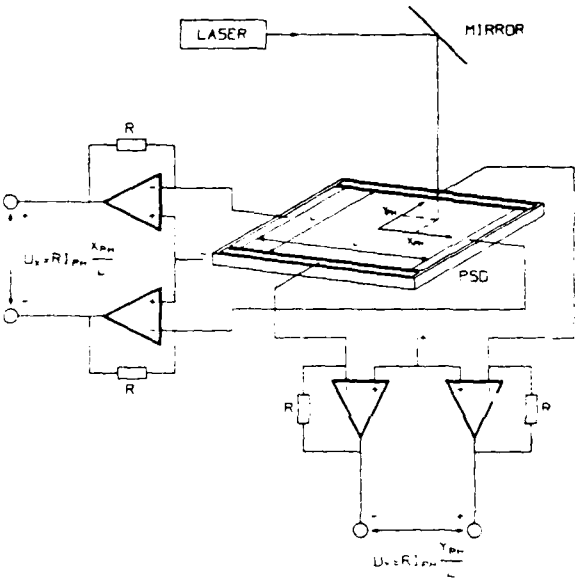

Figure 3. The PSD.

illuminated area. Electrons drift toward the lower n region, while holes drift toward the upper p region. In each resistive sheet, the charge carriers are divided between the two contacts, with the division ratio depending on the conductance between the beam incidence position and the contacts. Thus, proximity of the beam to a contact will cause a large portion of the generated photocurrent in the nearest contact and a smaller proportion in the farther contact. The light beam, in effect, acts as the movable, sliding contact of a potentiometer. The response is perfectly linear if: (1) potentials along the contacts are constant, (2) reverse bias is sufficient to prevent forward bias during illumination, (3) the p and n resistive sheets are homogeneous, and (4) leakage is insignificant. Of these, sheet homogeneity is most critical. Nonlinearity of less than 0.3% over a 15-mm × 15-mm sheet has been achieved.

M.N. Yoder

INSULATING FILMS ON SEMICONDUCTORS

The 1983 International Conference on Insulating Films on Semiconductors (INFOS) was held at the Univ. of Eindhoven, the Netherlands in April. Topics covered included interface states, oxidation, insulator impurities and growth techniques, charge carrier injection and trapping, breakdown, and characterization. Both elemental and compound semiconductor surfaces were addressed in sessions that included invited and contributed papers. The conference attracted over 125 participants; the proceedings will be published by the European Physical Society.

In addition to its widespread use in silicon logic devices, the inversion layer of the silicon metal oxide semiconductor field effect transistor (MOSFET) continues to be an extremely useful model for investigating electron transport phenomena. Such usefulness results from two characteristics: the two-dimensional electron gas in the inversion layer of the semiconductor immediately beneath the insulator, and the control of the Fermi energy and carrier concentration by the gate voltage. The properties of greatest interest include the optical and electrical characteristics of the inversion layer itself and the nature of the semiconductor-insulator interface. This article emphasizes the conference papers on inversion mode devices, to which most foreseeable INFOS applications are related.

Tunnel Injection Devices

Certain types of programmable read-only memories (PROMs), electronically erasable programmable read-only memories (EEPROMs), and silicon bipolar transistors with polycrystalline or amorphous emitters depend on tunnel injection across very thin (e.g., <14 nm) insulators. Various names have been given to the injectors--e.g., POLYDOX, SIPOS, Si-rich SiO_2, and O-rich poly Si. As MOSFETs are scaled to submicrometer dimensions, their control gate insulators must be made thinner, and the possibility of unwanted tunnelling must be considered. The main problem in fabricating tunnelling devices is to obtain uniformity of the tunnelling currents across the tunnel junction. For example, a 0.20-nm variation in thickness of a 4.00-nm-thick SiO_2 insulator results in a ten-fold variation in tunnel current.

P. Ged and colleagues (Centre National d'Étude des Télécommunications, Grenoble) have developed a procedure for fabricating tunnel junctions whose properties are very reproducible. The procedure begins with the growth on (100) silicon of a thermal oxide to a thickness of 50 to 60 nm. The oxide is then etched in a diluted buffered hydrofluoric acid solution held at 20°C. The etch rate is 0.70 nm/min and is monitored by spectroscopic ellipsometry with a sensitivity of 0.20 nm. Very large area junctions (e.g., 5 cm^2) are thinned to 4.1 ± 0.1 nm. At 1.6 V across the junction, 70% of the devices measured exhibited tunnel currents between 0.15 and 0.25 μA, corresponding to an average oxide thickness dispersion of 0.05 nm. Nearly 65% of the devices have only 0.01-nm dispersion and exhibit less than 30% tunnel current variation. Such average dispersion corresponds to a fraction of a lattice constant, thought virtually impossible to obtain. The 30% tunnel current variation, however, suggests short-range thickness variations not greater than two lattice constants.

A novel electron device was devised by J. Simmons (Univ. of Bradford, UK) in collaboration with I. Faraone and F. Hsueh (RCA Princeton Laboratories); it independently analyzes electron and hole tunnelling currents in thin oxides. The device is a p-channel silicon metal oxide semiconductor (P-MOS) FET conventional in all aspects except one: it has no direct contact to its drain. Instead, an aluminum-SiO_2 tunnelling contact is made to the n-type substrate immediately adjacent to the P+ drain region. Tunnelling oxide thicknesses ranged from 1.4 to 2.25 nm and were grown in dry oxygen at 700°C at a rate of 1.0 nm per 15 minutes. (Gate oxides were thicker.) Hole current through the tunnelling oxide was determined by measuring the FET source current, whereas electron tunnelling current comprised the entire substrate-to-ground current. Using a trapezoidal tunnelling barrier and a carrier effective mass of one half the electron rest mass ($0.5\ M_o$), the researchers found electron and hole barrier heights of 3.2 eV and 3.7 eV, respectively, for 2.0-nm oxides. This corresponds to an oxide band gap of 8.0 eV; a thick film oxide model thus appears to be valid for thin tunnel oxides.

Several methods have been used by different investigators to determine the thickness of thin tunnelling oxides. Among the most widely used are capacitance versus voltage, Shubnikov-de Haas oscillations at 4.2°K, Fowler-Nordheim tunnelling, ellipsometric, and transmission electron microscopy. D. Schmitt-Landsiedel and colleagues (Siemens AG, West Germany) have collaborated with P.

Pongratz (Technical Univ. of Vienna) to compare each of the methods on the same sample. The last three techniques were consistent and measured the oxide at 6.0 ± 0.1 nm. Initial results from the first two methods differed significantly. These measurements could be correlated with the other three only after it was determined that the first two measured the average distance of the electrons from the silicon surface. Using quantum theory to determine that the average distance of electrons from the silicon surface was 2.0 nm, Schmitt-Landsiedel and Pongratz found that the $Si-SiO_2$ transition region never extends beyond three atomic layers in depth and correlated the results of all five measurement techniques.

Low Temperature Process for Low State Density

As the lithographic dimension of transistors continues to be reduced, the control of impurity diffusion profiles becomes increasingly important. Perhaps the best approach to limiting diffusion is that of limiting all processing temperatures. Unfortunately, low temperature processing has not been compatible with obtaining the low interface state densities required for MOSFET logic devices. A new technique by R. Blanchet and coworkers (Electronics Laboratory, Central School of Lyon, France) appears to have overcome what had been thought to be a basic incompatibility. The fundamentally different approach not only reduces surface state densities at low temperatures, but it also provides the versatility of using insulators other than thermally grown oxides.

The key to the new technique is to treat the silicon surface with an energetic hydrogen plasma that has first been bounced off a silicon target. The plasma is thought to "heal" defects on the heated silicon semiconductor surface before deposition of the insulator. (In this respect, it may act like the more energetic hydrogen ion implantation used in amorphous silicon processing.) The insulator material is deposited by (1) ionizing the gas (e.g., oxygen, nitrogen, or both) in a plasma chamber, (2) accelerating it toward a sputter target (e.g., silicon or aluminum positioned at a 45-degree angle to both the ion beam and substrate) at an energy of 5 kV in a 500-μA horizontal beam, and (3) allowing the neutralized gas-target product to deposit on the underlying silicon substrate. Starting with a good base vacuum (e.g., less than 5×10^{-8} Torr), the film composition can be monotonically controlled between pure oxide and an 80% nitride. The controlled oxygen flooding of the substrate provides additional control over the oxide-nitride ratio. The substrate is held at room temperature during the insulator deposition.

Without the hydrogen plasma pretreatment of the silicon substrate surface, as-deposited interface state densities of 2 to 4×10^{13}/cm²·eV were typical and did not appreciably respond to further annealing treatment. In marked contrast, however, as-deposited interface state densities on surfaces pretreated by the hydrogen plasma were consistently 1×10^{12}/cm²·eV and responded favorably to subsequent low-temperature annealing in a nitrogen atmosphere at 300°C for 30 minutes. After the annealing treatment, researchers obtained virtually perfect capacitance versus voltage response, from which mid-gap densities of states below 1×10^{11}/cm²·eV were calculated. A total interface charge of 2 to 4×10^{11}/cm² was typical, with a flat band of 2 V. Metal-aluminum oxinitride-silicon structures typically resulted in interface state densities of 1×10^{11}/cm²·eV also. Even small mole fractions of oxygen led to breakdown fields exceeding 2×10^{6} V/cm.

Interface State Measurement

Various techniques have been devised for measuring the interface state densities on MOS capacitors of moderate size. The methods are, however, ill-suited to characterizing interfaces on very large scale integrated (VLSI) circuits whose individual gate control areas are exceedingly small and whose insulating oxides are thin. However, VLSI interfaces are the most interesting. They are also best suited for evaluating the integrated-circuit fabrication process itself, wherein semiconductor-oxide stresses may differ substantially from those in fat FET or other structures typically used for interface state characterization.

G. Groeseneken et al. (Catholic Univ. of Leuven) have resurrected the previously discarded charge pumping (CP) technique and adapted it for *in situ* interface state density measurements of MOS transistors. The researchers have closely examined the CP technique and have demonstrated that previous procedures were incorrect because they derived from a misinterpretation of the CP mechanism. The new procedure directly controls both the electron and the hole emission from interface states during the CP cycle. The new procedure is to pulse the FET gate and separately observe pulse rise and fall times. The former correspond to the lower part of

the gap, while the latter correspond to the upper portion. The procedure--somewhat similar to the well-known deep level transient spectroscopy technique--is capable of characterizing to within 0.06 eV of midgap at room temperature. As the limitation of midgap approach is based on the capture cross-sections of holes and electrons, a closer approach may be obtained at elevated temperatures. The absolute resolution at the band edges is determined by Fermi level and thus by doping. Sensitivities of $5.1\times10^{9}/cm^2\cdot eV$ are typical over the range ±0.375 to 0.1 eV from band edges. The greatest advantage of the CP technique is that a relationship between the surface potential and the gate voltage is not required; the method's limitation is that it provides virtually no information on capture cross-section of bulk traps.

InP MISFETS

The indium phosphide (InP) semiconductor exhibits a higher static peak electron velocity at higher electric field strengths than do other common binary or elementary semiconductors. It also is a better thermal conductor than gallium arsenide (GaAs). Unfortunately, InP is softer and more volatile than either silicon (Si) or GaAs and thus more difficult to process. GaAs tends to absorb oxygen on its surface, which disrupts the atomic bonding in a way that causes trapped electronic charges. In turn, the trapped charges pin the Fermi level at midgap and render it impractical for use as an insulator gate-controlled FET. In contrast, InP lends itself to inversion layer FET operation because oxygen is chemisorbed by the InP surface with a minimum of atomic bond breaking. The problems in using InP as a metal-insulator-semiconductor FET (MISFET) include minimizing surface state density and establishing both reproducibility and stability. Worldwide, a decade's work on solving these problems has resulted in some success.

Prof. J.J. Simonne (Laboratory for Automation and Analysis of Systems of the French National Center for Scientific Research) presented an invited paper addressing the state-of-the-art, trends, and prospects for InP MISFET technology. Simonne has been named chairman for INFOS '84, to be held in France.

His paper included 120 references to InP but concentrated on three categories of control gate insulators: native oxides, deposited insulators, and combinations of the two. He quickly dispensed with native oxides grown at room temperature by anodization because the associated problems of reproducibility and reliability (e.g., their hydroscopic nature) will probably not be easily overcome. On thermally grown native oxides, he stressed the problem of crystal disassociation from excessive phosphorous outgassing at temperatures much over 350°C. He also noted that thermal oxide composition varies a great deal and that reproducibility is difficult at best. An encouraging development recently is that thin (e.g., 10 nm) thermal oxides--when covered with chemical vapor deposited (CVD) insulators--have been used to fabricate MISFETs exhibiting good drain current stability. But surface state density and low mobility problems remain.

Simonne is particularly encouraged by recent progress with Al_2O_3 insulators formed by depositing a very thin layer of aluminum on the InP surface, plasma anodizing, and annealing in argon at 250°C. Resistivity (10^{14} Ω-cm) and breakdown (4×10^{6} V/cm) are good, as are surface state densities (4 to $7\times10^{11}/cm^2\cdot eV$) and mobility (2,500 cm^2/Vs). Unfortunately, trap centers increase appreciably for thicker oxides.

Deposited insulators are most versatile and circumvent the general problem of dielectric properties seemingly inherent in the native oxides. Al_2O_3-evaporated insulators have exhibited surface state densities in the $10^{11}/cm^2\cdot eV$ range after annealing but significant hysteresis in capacitance-voltage (C-V) characteristics remains. The most dramatic InP MISFET results have been made with SiO_2 grown by CVD at 380°C and annealed for 15 minutes. (The deposited SiO_2 is believed to prevent appreciable phosphorous outgassing at this temperature.) An InP power FET of 300-μm gate periphery exhibited an output power of 1.05 W at 4.0 GHz, which is 2.5 times the performance of a GaAs equivalent. Unfortunately, its transconductance deteriorated with age, and surface state density was $10^{12}/cm^2\text{-}eV$, thus rendering the approach inappropriate for logic devices.

Simonne feels that the best way to make InP MISFETs viable is to use low temperature plasma-enhanced CVD over a very carefully prepared and very thin native oxide. During the question and answer session after his paper, Simonne acknowledged that the most severe problem remaining is reproducibly to reduce surface state density of the very thin native oxides, and that this will be a difficult task until the defect level in the underlying InP substrate is substantially improved.

Insulating Films as Sensors

Dr. P. Bergveld (Univ. of Twente) is widely known as the father of ion-sensitive FETs, having published in 1970 the first paper on the subject. The conference was privileged to hear his invited paper on devices for measuring the pH of liquids. Investigators at Twente are concentrating on a model based on the reactivity of inorganic insulators in contact with electrolyte. The premise is that surface sites on the insulator react selectively with ions in the solution, creating charged layers and a corresponding potential distribution in the electrical double layer at the liquid-insulator interface in the electrolyte. The recent Twente contribution is a rewriting of the model in terms of interfacial potentials instead of the number of charges, as has been traditional. Thus, experiments can be more easily correlated with well-known flatband voltages on C-V measurements used to characterize conventional FETs. With the Twente model, it is a straightforward process to derive and compare with measured data the small signal impedance of a liquid-insulator-semiconductor system. The researchers found that the model not only explains the very short response times of certain insulator-sensing systems, but also shows that the interfacial impedance is very low for insulators with high surface reactivity and much larger for unreactive surfaces.

M.V. Yoder

MATERIAL SCIENCES

FIBER COMPOSITE MATERIALS IN THE UK: UNIV. OF OXFORD AND ICI

This is the third in a series of articles reporting research activities on fiber composite materials in the UK. Research at the Univ. of Oxford and Imperial Chemical Industries (ICI) is highlighted this month.

Univ. of Oxford

Composite materials research at the Univ. of Oxford is conducted in the Department of Engineering Science. The overall research program covers a broad spectrum of topics, ranging from fluid mechanics, thermodynamics, medical engineering, and plasma physics to control, system dynamics, and robotics. There are 39 academic staff, 42 post-doctoral research workers, and over 80 research students.

Dr. John Harding leads the research on fiber composites, emphasizing high speed deformations (see R.W. Armstrong, ESN 37-3:105-111 (1983)). A major effort has been made lately in the development of a tensile testing technique for fiber composites at impact strain rates. In an article to appear in the [illegible], Harding and L.M. Welsh give a detailed review and evaluation of the experimental techniques that have been used in attempts to determine the mechanical properties of composites under impact loading. They also discuss the difficulties encountered in the design of a satisfactory tensile impact test machine for composite materials.

In the original form of tests of the Hopkinson bar, the test specimen is sandwiched between the ends of loading bars; the incident, reflected, and transmitted stress waves are determined from strain gages attached to the bars. In the standard tensile version of the apparatus, the input loading bar becomes the wave bar into which the output, or gripping, bar slides freely; the specimen screws into the ends of the yoke. For tests of unidirectional specimens, the apparatus allows one to find the dynamic flow stress at a strain rate with reasonable accuracy; the gage length of the specimen must be short enough so that an approximate stress equilibrium across the specimen has been attained during the early stages of the test. When the test is used for composite materials, several major problems arise. It is difficult to ensure a tensile failure in the gage section rather than a shear failure in the grips. Stress concentrations associated with the anisotropic nature of the material must be minimized so that significantly longer test specimens are required. The length makes it more difficult to attain stress equilibrium across a specimen. In addition, since for most composite materials the total strain to failure is only a small fraction of that obtained in metal specimens, the accurate determination of strain becomes much more critical.

To correct the above shortcomings, Harding and coworkers have developed a modified version of the tensile split Hopkinson's pressure bar (SPPB) apparatus for the tensile impact testing of unidirectional fiber composites. There is an instrumented input bar preceding the specimen and the inertia bar; the input bar can slide freely in the weight-bar tube. Strain gages at two stations on the input bar monitor the incident and reflected waves in the test specimen itself. Thus, the validity of

the assumption of stress equilibrium across the specimen can be directly checked, and strain in the specimen can be determined from measurements taken in a single test. It is not necessary to compare results from two tests that might be sufficiently different to reduce measurement accuracy.

Tests based on the modified SHPB apparatus have been performed to obtain stress-strain responses of 0-degree carbon fiber reinforced plastic epoxy (CFRP), and 0-degree and 45-degree glass fiber reinforced plastic epoxy (GFRP). The two materials show significantly different behaviors. For CFRP specimens over nearly seven orders of magnitude (0.0005/s ~ 450/s), no effect of strain rate could be detected on either the tensile modulus, 146 ±6 GPa, or the stress at fracture, 1.2 ±0.1 GPa. In contrast, for both orientations of GFRP specimens, the maximum stress preceding failure increased dramatically with strain rate--from 348±35 MPa at 10^{-4}/s to 899±28 MPa at 870/s for 0-degree specimens, and from 212±12 MPa at 2.5×10^{-4}/s to 392±38 MPa at 1,120/s for the 45-degree specimens. Furthermore, in the 0-degree specimens, a marked effect of strain rate was apparent on the modulus, which increased from 19.6 ±0.9 GPa to 48.6 ±2.9 GPa over the same range of strain rate. As for the fracture mode, the CFRP specimens at all strain rates show tensile failure in the center of the parallel gauge region with little damage to either side of the fracture surface. In contrast, a marked change in fracture appearance with strain rate was observed in tests on 0-degree GFRP specimens. At quasi-static rates, damage was limited to regions close to the fracture surface. In tests at increasing impact rates, the damage extended further from the fracture surface, covering the entire gauge region--i.e., well beyond the 6-mm parallel section.

The differences in the responses of initial elastic modulus, fracture strength, fracture strain, and failure mode for CFRP and GFRP naturally lead to very different energy absorbing capabilities. The energies absorbed per unit volume in fracturing the specimens at impact rates, as determined from the area under the stress-strain curves, are 5.0 MPa for 0-degree CFRP, 18.5 MPa for 0-degree GFRP, and 32.9 MPa for 45-degree GFRP. The findings show that hybrid CFRP/GFRP composites should be used for their improved toughness, providing the best overall composite mechanical behavior.

ICI

Fiber composite research at ICI is done primarily by the New Materials Group, formed about 2 years ago. This group drew upon the talents of the Petrochemicals and Plastics Division and Mond Division. A major research effort is devoted to polyetheretherketone (PEEK) composites; about 15 professionals are involved. Dr. Neil Cogswell was my host.

"Victrex" PEEK is a relatively new aromatic polyether developed by ICI's Petrochemicals and Plastics Division. A high-performance thermoplastic polymer, "Victrex" PEEK is suitable for processing by extrusion or injection molding. It was developed primarily as a coating and insulating material for high-performance wiring, which is subject to stringent requirements for heat resistance, flammability, and chemical resistance. "Victrex" PEEK is supplied as dry, free-flowing granules and is readily processed. Some of the physical and mechanical properties of unfilled "Victrex" PEEK are as follows: melting point, 334°C; glass transition temperature, 143°C; maximum crystallinity, 48%; specific gravity, 1.265 to 1.32; processing temperature range, 370 to 400°C; tensile yield strength, 100 MPa; tensile yield strain, 0.06; elongation to break, 150%; tensile modulus at 150°C, 1.1 GPa.

In November 1982, ICI introduced the first commercial, continuous-fiber, thermoplastic preimpregnated material, or "prepreg." It is based on carbon fiber impregnated with PEEK and is called Aromatic Polymer Composite (APC-1). According to Cogswell, the advantages of APC-1 are indefinite shelf life, enhanced damage tolerance, and high-rate fabrication by a range of technologies adapted from metal working or from traditional thermoset processing. APC-1 also can be repaired, and scrap material can be reclaimed as a high-quality injection molding compound.

The prepreg of APC-1 has highly collimated fibers with uniform random fiber packing; the thickness of the resin phase is comparable to that of the fiber, ~7 μm. Typical processing cycles of APC-1 involve the transfer of molten sheet at 380°C to a molding operation, where the mold usually is at a temperature from 20 to 200°C. It has been found that the morphology of the resin is not significantly dependent on the processing history when the composite is cooled from the melt to a temperature in this range. The crystallinity of the resin phase is estimated at about 35%, and the spherulite size is about 2 μm. The resin derives its imperviousness to

chemical attack from its crystallinity. Furthermore, the presence of intense nucleation of resin crystallites at the fiber surface is believed to be responsible for the excellent adhesion between resin and fiber phases in APC-1.

The energy absorption mechanisms in APC also have some unique features. Micrographs of broken sections indicated that no "clean" fibers were pulled out of the resin and that fibers on the fracture surface were always coated with resin. The micrograph observations substantiate the strong fiber-matrix bonding due to resin crystallization nucleated at the fiber surface. Thus the conventional interpretation of energy absorption due to fiber-matrix debonding and fiber pull-out is not applicable to APC.

Cogswell and coworkers suggested that the high toughness of APC is due to two factors. First, the large plastic zone size at the tip of a crack is more than three times the resin thickness between adjacent fibers. Second, consider a tear propagating through the composite. Because of the excellent adhesion at the interface, the fiber must break where it is met by the tear. From the standpoint of the statistics of fiber strength, on such a short gauge length the fiber is inherently stronger than would be the case with interface failure and subsequent fiber failure at a weak spot. It is also interesting to note that APC, unlike some thermosetting resin composites, does not develop transverse cracks until the failure load is approached. There is no evidence of delamination under impact load, and very limited delamination is observed under penetration tests. Double cantilever beam tests have shown that the fracture toughness (G_{IC}) value of APC is nearly 10 times that of epoxy composites. Furthermore, the high interfacial bonding strength in APC tends to activate shear failure modes under compression. APC-1 also can be machined easily.

The cost of APC-1 prepregs is now about twice that of carbon-epoxy. However, because of the relative ease of processing, in general it may be more economical to use thermoplastic instead of thermosetting composites.

T.-W. Chou

MATERIALS AT THE UK DEFENSE COMPONENTS EXPO 83

The third Defense Components Expo (DCE) was held at Brighton, England, from 10 through 12 May 1983. DCE 83 consisted of an exhibition and symposium concentrating on the component parts of major weapons systems for the attention of designers, development engineers, and procurement officers. Advanced developments in defense-related aspects of new materials, devices, and processes were the subjects of 148 industrial exhibits and 24 symposium speakers from industrial and government establishments. The part of DCE 83 relating to materials is the subject of this article.

The meeting was sponsored by the UK Defense Manufacturers Association (DMA). About 350 British companies are members of the DMA, which is interested in defense systems, ancillary equipment, components, materials, and specialized services for British forces and overseas defense markets. The DMA produces an informative bulletin; inquiries should be addressed to The Defense Manufacturers Association, 136 High Street, Guildford, Surrey GU1 3HL, England.

Materials-Related Topics

R.J.E. Glenny (Royal Aircraft Establishment [RAE], Farnborough) chaired the opening symposium session: New Materials and Materials Forming. G.B. Brook (Fulmer Research Laboratories Ltd.) presented a paper on "Semi-Solid Injection Casting of Aluminum Alloys." A new process has been developed at Fulmer to produce pore-free pressure die castings of polyphase alloys that can then be subjected to heat treatment without adverse shape or dimensional changes. The proprietary casting procedure, which is claimed to be competitive with rheocasting, was mentioned by R.W. Armstrong and V.T. Stannett in "Fulmer Research Institute Ltd.," *ESN* 36-9:211-213 (1982). The process utilizes a controlled microstructure within accurately sheared billets from a continuously cast bar produced nearby. The billets, having a relatively fine microstructure of globular primary phase particles, are heated to a semisolid, thixotropic state containing 50 to 60% solid material. In this condition, the billets can be handled as soft solids, which are injection cast in the same type of apparatus used for conventional die casting of liquid alloys. The problems of liquid spraying, turbulent flow, and internal oxide films encountered with liquid die casting processes are avoided.

Strength levels approaching those of forgings are achieved in the new pore-free products. A pilot plant is in operation. In the stationary state, the soft solid can be robot-loaded into the

die casting machine, which then forces a viscosity reduction for the billet by a high loading rate and gives turbulent-free filling of the die cavity without porosity. The viscosity dependence on impressed deformation rate is optimized for any specific volume of material to give laminar flow for efficient die filling.

The technical details for the operation are as follows: a Technica Guss casting machine first produces continuously cast Al-6% Si-4% Cu alloy to the British specification BS 149:LM21 condition; then a Red Ring Model 150 automatic high pressure die casting machine gives the finished item. The machine is from Precision Gear Machines and Tools Ltd.; it has a modified injection system allowing high forces to be maintained for the total injection stroke. Brook suggested that future developments should allow direct forging of such materials without any element of the die casting process being necessary.

J.R.B. Gilbert (IMI Titanium Ltd.) presented an excellent paper on "The Use of Titanium in Defense Applications." While introducing Gilbert, Glenny pointed out that IMI Titanium is the only UK melter of titanium and is the foremost European supplier of the material.

Gilbert said that today titanium is primarily used in aircraft and helicopter engines. The blades and disks in the compressor section of the Rolls-Royce Pegasus engine powering the Harrier jump-jet are made from IMI 318 and IMI 550 alloys, respectively. A drum from welded disks of creep-resistant IMI 685 and IMI 829 alloys was shown for the Rolls Royce/Turbomeca, Adour engine, which powers the Hawk and Jaguar.

Besides the use of titanium in engine parts, Gilbert described titanium alloys for structural parts in aircraft and helicopters, such as the highly stressed mounting brackets, flap tracks, and weapon-carrying points. Titanium is employed in gas turbines in ships and in radar components, sonar heads, ventilator fan blades, heat exchangers, and nonmagnetic bolts. The Russian 18,000-ton Alpha class submarine has a titanium alloy hull for which the problem of welding thick sections apparently was overcome by submerged arc techniques and alloy development.

Gilbert estimates that the free-world capacity of titanium probably exceeds that of the USSR again. IMI is now producing 10-ton ingots and could make 17-ton ones with minor modifications to their latest furnace. Many titanium alloys can be superplastically formed and diffusion bonded. Machining difficulties are overcome to some extent by low speed, heavy feed operations on rigid equipment. Casting requires special nonreactive molds and vacuum equipment to avoid oxygen uptake.

E.M. Trewin (Hysol Grafil Co., associated with Courtaulds) gave the paper "Developments in Carbon Fibers" for composites applications to airframe and other defense needs. Polyacrylonitrile (PAN) has become the dominant starting material (precursor) for conversion by controlled pyrolysis in a three-state heating process involving oxidation, carbonization, and graphitization to produce strong, stiff carbon fibers. Between 1,000 and 30,000 filaments are combined in a single "tow" rope in a dedicated textile-type facility for the three-stage operation--first in an air atmosphere at 200 to 250°C, then at 1,500 to 2,600°C for the two following heat treatments. Precursor control was said to be critical to determining the quality of the final product. Courtaulds sells the material at several of the processing stages: special acrylic fiber (SAF) precursor material; oxidized fiber, Grafil 'O,' for thermally resistant materials; and Grafil XA-S high-strength (3.0 GPa) carbon fibers or Grafil HM-S high modulus (300 GPa) graphite fibers. New developments are being made in the area of high strain fibers giving about 2% extensional strain.

Carbon fiber reinforced plastic (CFRP) material in the form of a graphite-epoxy composite covers 50% of the surface area of the McDonnell Douglas F18 airframe. Carbon-epoxy based on the Graphil SAF precursor accounts for 26% of the structural weight of the British AV8B. British Aerospace is translating demonstration projects for wings, fuselage, and brakes into increased usage for production. The Learfan 2100 has 75% of its airframe in carbon-epoxy material. Helicopter blades, missiles, and rocket motor cases are other applications. The 200-ton annual production of carbon fibers by Courtaulds, representing 90% of European production, is to be increased by 70% this year. Trewin suggested that a strength limit of 10.0 GPa should be obtainable. In addition, a modulus increase to 700 GPa might be reached by hot stretching during production; but thus far the procedure has decreased the strength.

N.J. Parratt (Composite Development and Applications; Propellants, Explosives and Rocket Motor Establishment [PERME]) followed with the paper titled "High Performance Composites Generated by Rapid Processes." In cost per unit

load carried, the carbon fiber reinforcements introduced by RAE fell between aluminum and titanium. PERME has been developing low cost methods for using composites such as CFRP. For combined tension and compression loading, the CFRP material is more balanced than the orientated aromatic polyamide (Kevlar®) reinforced epoxy because of the lower compressive strength of Kevlar. Just as high tensile strength wire was wrapped around gun barrels to strengthen them, CFRP material is used to strengthen rocket motor casings (see the historical item by R.W. Armstrong and D.L. Mott in *ESN* 36-8:197-198 [1982]). PERME was trying pressure casting into reinforcement skeletons by injection casting or squeeze-forming procedures. Deformable CFRP material was made by chopping the carbon fibers up before aligning them in sheet material. The chopped fibers were proposed to give a deformable composite competitive with super-plastic forming of metals. A length of 3.0 mm for the fibers gives over 90% retention of properties, including an improved fatigue strength. If a thermoplastic resin is used rather than epoxy, shaped parts can be stamped from sheet--much like pressing steel. Much work has yet to be done in the area of "blending"; in one case, for example, when an amount of brittle, high-modulus carbon fiber was added to a high tensile strength glass-carbon mixture, a clustering effect of the mixed fibers stiffened the material without lowering its strength.

F.W.L. Hill (Raychem Ltd.) gave a paper on "Materials With Memories," covering the shape-memory effect for radiated cross-linked polymers and extended since then to spontaneous (martensitic) phase transformations in metal systems. Such activity is pursued at Fulmer as well (see *FSN* 36-9:211-213 [1982]). Heat-shrinkable sleeves are used in aircraft and submarine couplings. Connectors have been designed for the Trident missile system and for microelectronic pin-grid arrays.

A.J.N. Hope (Barr and Stroud Ltd., Glasgow) delivered the paper "Infra Red Optical Materials and Coatings." Thermal imaging and gunnery fire control, including laser range finding systems, are important defense applications. Materials produced at Barr and Stroud are germanium, chalcogenide glass, zinc sulfide, zinc selenide, silicon, and calcium aluminate. Much work is done on antireflection coatings to overcome the surface reflection dependence on refractive index. A very durable, diamond-like coating has been developed for germanium. Alkali halides would be suitable cheap materials. However, their hygroscopic properties present problems; work on a solution continues.

G. Williams (Automotive Operations, GKN Sankey) gave a paper on squeeze forming, which involves the solidification of liquid metal under pressure in reusable dies. The process has been applied to aluminum casting and forging alloys in which strength levels approaching those of forgings have been obtained. Pressures from 30 to 110 MPa are generally involved. Parting agents are important for removing the product. Squeeze forming, like the semisolid metal injection process described by Brook, lends itself to robot control, so the two processes are competitive to some extent. Fine microstructures are obtained; an advantage is that relatively isotropic strength properties are achieved. In addition, fewer processing steps are involved than for forging, and the time for solidification is appreciably less than in conventional casting. Ballistic covers and tank wheels have been produced.

H.T. Gisborne (Sheffield Forgemasters, formerly Firth Brown Ltd.) gave the final paper, "Novel Forging Techniques Using the SX65 Forging Machine." This is the largest forging machine in the western world and has a high speed of operation. Two pairs of forging hammers operate at right angles to each other. High-strength nickel base and superalloy materials can be handled. Fine uniform grain sizes can be obtained. High pressure gun barrels 8-m long have been produced. Co-forming of composite high- and low-carbon steel alloys was accomplished with complete welding of the materials at large forging reductions.

New Devices and Processes

Two sessions were held on new devices and processes. The programs are reported here. G. Pearson (Royal Armaments Research and Development Establishment [RARDE]) chaired a session covering the following presenters and their papers: J. Varley (Self Changing Gears Ltd.), "Military Transmissions--Driving Ahead"; S. Dowling (Horstman Defense Systems Ltd.), "Rotary Hydraulic Suspension Damper for Tracked Vehicles"; A.J. Woolgar (Image Intensifier Department, English Electric Valve Co. Ltd.), "Developments in Image Intensifiers for Night Vision Applications"; J. Tuffen (Keymed), "Advances in Rigid and Flexible Optics in Security"; M.J. Newman (RARDE), "Electromagnetic Guns"; R.L. Farquhar (Graviner Ltd.), "Fire-Fighting--AFV's Survivability Systems"; F.A.

Myers (Plessey Research Ltd.), "Gallium Arsenide Microwave Devices in Defense Applications"; J. Brown (Marconi Electronic Devices), "Current Trends in Electronic Packaging."

LTG Sir Hugh Cunningham, KBE, chaired the concluding session: M.J. Wood (Aish and Co. Ltd.), "Electronic Compatibility"; R. Heighington (Plessey Assessment Services Ltd.), "Investigating Reliability of Military Systems by Long Term Environmental Testing"; J. Evans (British Aerospace), "Laser Developments"; R.J. Kirby (Superflexit-Icore), "Developments in Flexible Electrical Conduit Systems"; J.F. Dickson (Allen Clark Research Center, Plessey Research Ltd.), "New Silicon Integrated Circuits for Military Applications"; R. Grantham (Security Research Ltd.), "Counter Surveillance and Access Control Units"; F. Brewer (A.T.A. Group of Companies), "Trends in Weapon Training Systems"; and R. Curtis (Weston Simfire), "All Arms Battle Field Tactical Simulators."

The symposium coverage well illustrated the DCE theme, "Technology--A Key to National Security."

Exhibition

A list of products exhibited was catalogued under 359 headings, including materials-related items such as armor plate, batteries, CFRP materials, castings, ceramic components, composite materials/structures, explosives, fiber optics systems and equipment, infrared materials, investment castings, metals, nondestructive testing equipment, optical coatings, plastics, printed circuits, radioactive materials, semiconductors, special metals/alloys, tubes, tungsten alloys, uranium alloy penetrators, welding equipment, and wire materials. Among the exhibitors were Doncasters Special Alloy Products Ltd., showing forged and machined components of nickel base, titanium and aluminum alloys, and stainless and special steels; Finecast Ltd., showing lost wax investment castings; Nobel's Explosives Company Ltd., showing solid propellants and accessory equipment; Steatite and Porcelain Products Ltd., showing ceramic components and armor; and Electron Beam Processes Ltd., showing a variety of welded components. The National Engineering Laboratory (East Kilbride, Glasgow) presented information on technological developments for precision forming of metal components and for flexible manufacturing systems and robots. A demonstration was given of products from the 13 stations of the Royal Ordnance Factories.

A closing example of the strong connection between scientific research, development, and defense applications is provided by an exhibit by Micro Consultants Ltd. Applications of their INTELLECT 100 and 200 digital image processing, generation, and enhancement computer systems were described for tracking, radar, image analysis, sonar displays, aerial reconnaissance, infrared imaging, pattern recognition, and nondestructive testing relating to defense purposes. Readers of *ESN* might note that the INTELLECT 200 is shown in Figure 1 of "Metallurgy and Materials at Oxford," *ESN* 37-3:105-111 (1983), which describes the image analysis system developed for performing high resolution electron microscopy of material microstructures on the atomic scale.

R.W. Armstrong

MATERIALS-RELATED DEVELOPMENTS IN IRELAND

The combined effects of international investment in Ireland and its entry into the European Economic Community (EEC) have spurred materials-related developments in the country. National emphasis has been given to producing technically trained graduates for employment in new industries and to promoting communications with counterpart researchers in the EEC and the US. This article focuses on work at Trinity College, Dublin; Cork Regional Technical College, Bishopstown; The National Institute of Higher Education (NIHE) and European Research Institute of Ireland (ERII), both at Limerick; and University College, Galway.

Trinity College

D.M.R. Taplin, previously at the Univ. of Waterloo, Canada, is Professor of Engineering Science in the Department of Mechanical and Manufacturing Engineering. Taplin is continuing work at Dublin on creep fracture in association with colleagues at Waterloo and at Chalmers Univ., Sweden. Figure 1 shows a transmission electron micrograph of cavities approximately 10 nm in diameter at a grain boundary in a Cu-1% Cr industrial alloy subjected to low-cycle fatigue testing at 400°C. N.Y. Tang, also from Waterloo, is a research fellow at Trinity College. With G.L. Dunlop, visiting fellow at Trinity and Chairman of the Materials Center at Chalmers, and

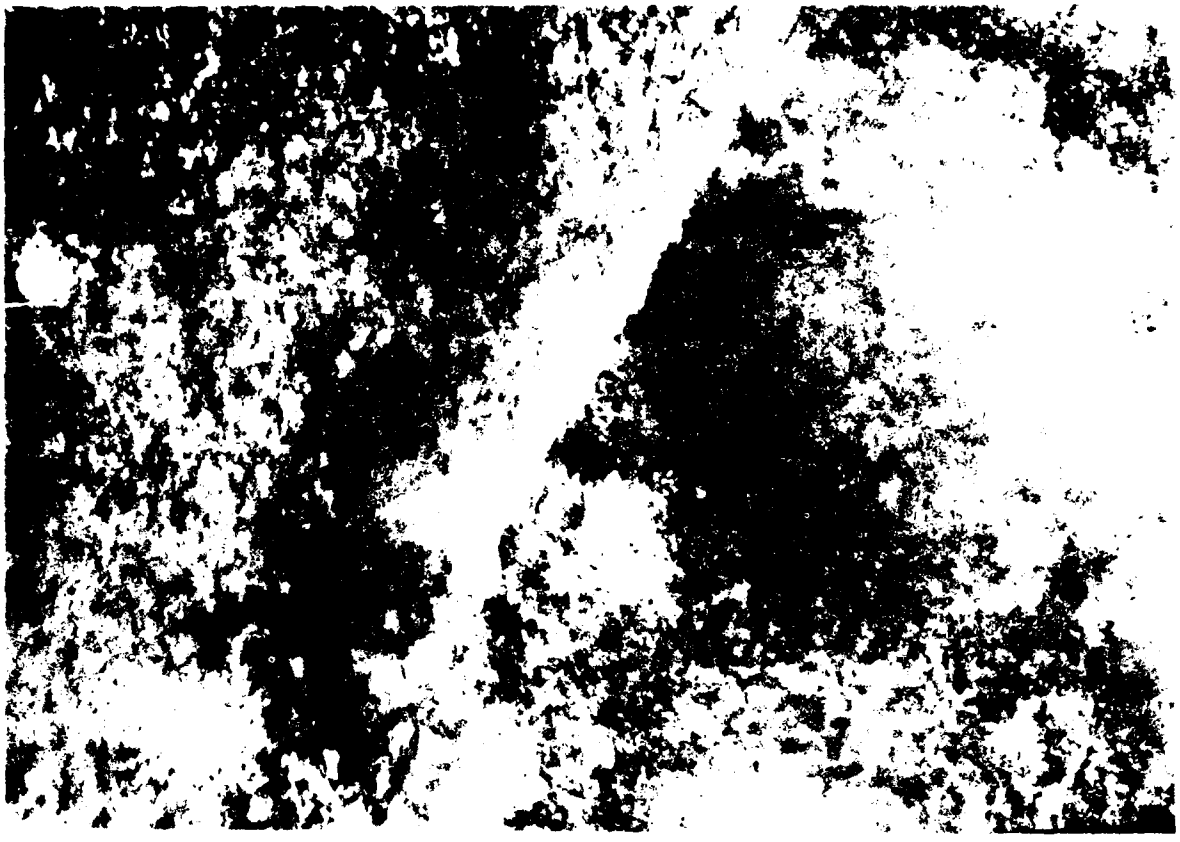

Figure 1. Grain boundary cavities, approximately 10.0 nm in diameter, appear as white circles along the inclined grain boundary of a Cu-1%Cr alloy subjected to low-cycle fatigue damage at 400°C. Note the grain boundary offsets due to shear deformation (Tang and Taplin, 1983).

Colette O'Meara, Taplin is beginning a project on the effect of high temperature oxidation on the creep behavior of yttria β-sialon, a Si-Al-O-N ceramic based on the β-Si_3N_4 structure. The work relates to the current EEC collaboration on science and technology (COST 501) program concerned with ceramic materials for engineering applications at high temperature (*ESN* 37-1:21-24 [1983]).

Other faculty and their interests within the department include: W.G. Scaife, high pressure measurements for equation of state studies (Scaife and Lyons, 1983); D.W.A. Rees, anisotropic yielding and work hardening in the continuum theory of plasticity (Rees, 1982); J. Fitzpatrick, assessment of random fatigue damage; M. El Baradie, cutting tool and failure mechanisms; A.A. Torrance, abrasive wear and corrosion; and D. Taylor, microstructural aspects of fatigue crack growth thresholds and propagation (Taylor 1982).

Scaife is chairman of the First Parsons International Turbine Conference to be held from 26 through 28 June 1984 at the Parsons Building, Trinity College. The conference marks the centenary of Charles A. Parsons' inventing the first practical steam turbine. Keynote topics will include blade design and fluid mechanics, shaft dynamics of bearings and foundations, influence of material properties on design, control problems, manufacturing technology, and special operating demands. Abstracts of about 300 words are invited to be submitted to Scaife before 1 October 1983.

As part of COST 501, Rees, Taylor, and Taplin are involved in a joint project on uniaxial and multiaxial creep and fracture behavior of tubular components in an aggressive environment. The

work, like a project at the UK National Physical Laboratory, relates to the multiaxial creep fracture of nickel-base superalloy materials.

Taplin is President and Chairman of the International Congress on Fracture (ICF) from 1981-85. ICF6 is scheduled for 4 through 10 December 1984 in New Delhi, India. The First Irish Durability and Fracture Conference, IDFC 1, was chaired by Rees and held at Trinity College on 9 and 10 March 1983; the topic was Environmental Effects in Materials Science. IDFC 2 is scheduled for 28 and 29 March 1984 at Limerick; the topic will be Mechanically, Chemically, and Thermally Induced Failure in Engineering Materials. Work on metals and alloys, ceramics, and polymeric materials is of interest. Abstracts of approximately 200 words should be submitted by 16 September 1983 to Dr. J.D. Bolton, Department of Materials Engineering and Industrial Chemistry, NIHE, Limerick, Ireland.

Cork Regional Technical College

L. McDonnell and E. Cashell are active in research and teaching of instrumentation and applied physics. McDonnell and Lawless (1983) have reported the development of an apparatus for performing *in-situ* Auger electron spectroscopy of steel weldment fracture surfaces to assess the importance of chemical segregation effects (Figure 2).

McDonnell is active in the Ireland Section of the Instrument Society of America (ISA). Instrumentation Ireland, a conference jointly sponsored by ISA and the Ireland ISA Section, is to be held from 15 through 17 May 1984 at the Royal Dublin Society Exposition Center.

Cashell is interested in photoacoustic microscopy, whereby microstructural observations of cracking effects can be observed by the thermal generation of acoustic signals from absorbed optical energy (Rosencwaig, 1982). The plan is to investigate whether the method can be coupled with the fracture surface analysis system to provide combined results. It has been helpful that an Institute for Industrial Research and Standards (IIRS) facility was built next to the Regional Technical College. The IIRS staff is interested in acoustics monitoring of quarry blasting, for example.

NIHE and ERII

The NIHE was established at what has now become Plassey Technological Park, which also includes the ERII, the Industrial Development Authority, Innovation Center for Small Industry, IIRS, Intest Systems Ltd., Irish

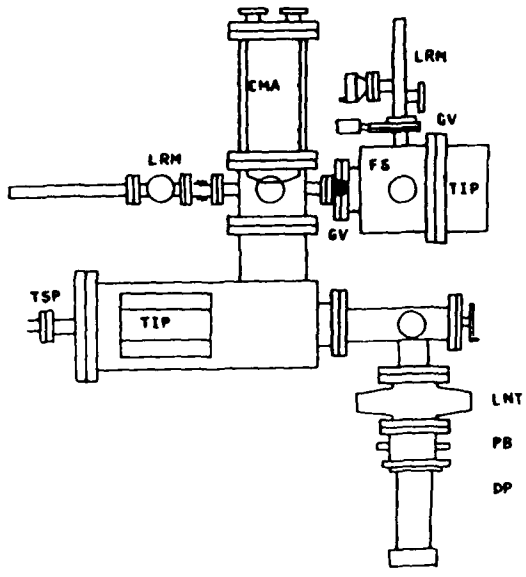

Figure 2. Auger electron spectroscopy system designed for *in-situ* fracture surface studies: LRM--long reach manipulator, CMA--cylindrical mirror analyzer, GV--gate valve, FS--fracture stage, TIP--triade ion pump, LNT--liquid nitrogen trap, PB--Peltier baffle, DP--diffusion pump, TSP--titanium sublimination pump (McDonnell and Lawless, 1983).

Productivity Center, Local Government Computer Services Board, National Electronic and Testing Center, National Metrology Center, National Microelectronics Applications Center, Regional Management Center, Thurmond College of Education, Varian Instruments Ireland, and Wang Laboratories Ireland.

E.R. Petty is Professor and Head of the Department of Materials Engineering and Industrial Chemistry, NIHE. The department's activities cover metals, ceramics, and polymers. J.D. Bolton is conducting research on prosthetic materials and on the fracture toughness properties of hard, brittle materials, including tungsten carbide, silicon nitride, sialon, and ceramics. Corrosion fatigue results on a cast cobalt alloy have been reported by Bolton, Hayden, and Humphreys (1982), and fatigue crack growth rates have been measured for a number of 316 grade stainless steels (Bolton and Redington, 1982). Bolton and Keely (1983) reported on the fracture toughness of cemented

carbides, particularly the WC-Co alloy systems.

C. O'Meara, from Trinity College, has done preliminary transmission electron microscopy work with Bolton on dislocations in sialon. S. Hampshire is continuing at NIHE the work done with Prof. K.H. Jack, FRS, Univ. of Newcastle-upon-Tyne, on the crystal structure of sialon materials and their phase transformations (Hampshire and Jack, 1982). Hampshire's interests include liquid phase sintering, glass formation, and thermo-mechanical properties of ceramics and glasses. D.E. Taylor is concerned with electrochemistry, catalysis, and corrosion. Corrosion fatigue, fretting corrosion, and corrosion aspects of nuclear reactor safety issues are special concerns.

The ERII mainly promotes research and development in electronics, energy and chemical process engineering, and industrial and systems engineering. A materials-related activity has been their involvement as consultants to Howmedica International Ltd. on quality control of investment casting of hip joint prostheses. The Georgia Institute of Technology manages the ERII.

University College, Galway

Prof. J.F. McNamara heads a small group of materials-related faculty in the Mechanical Engineering Department. P.J. Mallon has done research on constitutive relations for polymers and is now turning to composite systems. With M.G. Lane, McNamara has investigated the influence of nonlinearities in fatigue calculations for determining the life of offshore structures according to their stress histories. The nonlinearities are proposed to be so important generally as to make unreliable spectral methods of analysis, which are strictly applicable to linear systems.

McNamara's main interest is in computing and its applications to materials and other engineering problems. He is doing an interesting project on behalf of the Irish Government, which has been involved with the International Energy Agency. McNamara has been evaluating the performance of the Japanese wave energy absorbing ship *kaimei* during its initial sea trials at Yura in the Sea of Japan (Conroy, Dooley, McNamara, McNamara, and O'Flaherty, 1982). The cost of wave energy from the ship is too high, apparently, for the foreseeable future. A recent UK development on wave power is that Vickers, the engineering group, claims that power can be provided ashore at 7.5 cents per kilowatt-hour from a plant which could be built off the outer Hebrides, but the Department of Energy seems to have lost interest (*Fl. Times* [London], 19 May 1983).

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R. W. Armstrong

PHYSICS

A SITING PROPOSAL FOR ESRF

Research into the ionic and electronic structure of condensed matter is at the intellectual forefront of physics and is the basis for many solid state applications to electronics, materials science, industrial and life chemistry. Many recent advances in these areas have been made possible by the ability to probe matter with the synchrotron radiation emitted by high energy electron beams circulating in storage rings.

The unique properties of such radiation that benefit condensed matter research are a broad spectral range, a high intensity, a high degree of collimation, precise timing and polarization structures. (See the articles by D. Mosher and R.W. Armstrong in ESN 36-12 (1982).) Because of these benefits, according to the Lynch Report recently released by the Solid State Sciences Committee of the National Academy of Sciences, US users of synchrotron radiation have increased by 20% per year for the last 5 years. Associated publications rose by 30% per year. The report states that the number of users in the x-ray regime is now about equal to the capacity of operating and newly funded facilities.

The demand for x-rays has been stimulated by the development of focusing optics to concentrate the radiation and by the use of insertion devices (wiggler and undulator magnets) to enhance the intensity emitted in the x-ray regime. With such magnets, recent advances have been made in the measurement of x-ray absorption by detecting fluorescent lines and Auger electrons, and in the measurement of x-ray diffraction and scattering to determine the time-dependent and two-dimensional structure of proteins, melting surfaces, adsorbates, and membranes. The measurements rely on x-radiation provided by the higher energy storage ring facilities and can benefit from increased source brightness because of improved photon statistics and higher resolution.

Condensed matter research is conducted at many facilities in the world, but most are not dedicated to that research and only a handful provide most of their radiation in the x-ray regime. Dedicated x-ray facilities (beam energy in the few-gigaelectronvolt range) are the Synchrotron Radiation Source (SRS) at the Daresbury Laboratory (Warrington, UK) and the newly commissioned x-ray ring at the National Synchrotron Light Source (NSLS, Brookhaven, NY). Comparable facilities for research, though part time for condensed matter studies, are the ADONE ring (Frascati, Italy) and DCI (Orsay, France). Dedicated synchrotron rings in Japan, at Stanford, and Cornell operate part time as they share common injector accelerators with high-energy physics users.

Faced with a rapidly increased demand for high quality x-ray beams, the European Science Foundation (ESF) established an ad-hoc committee chaired by Y. Farge of the Univ. of Paris Sud to prepare a feasibility study for a European Synchrotron Radiation Facility for X-rays (ESRF) dedicated to condensed matter research. Following release of the report by the committee, ESF called for proposals for the siting of ESRF. In response, the Danish Natural Science Research Council, in collaboration with the Risø National Laboratory, prepared a feasibility study for siting at Risø. In a talk presented at the International Facilities for Physics Research conference (Copenhagen, Denmark, 21 through 23 March 1983), B. Buras, director of the ESRF project at Risø, discussed machine parameters, the need for the new device, and the advantages of siting at Risø.

As described by Buras, ESRF would be a 5-GeV ring with a 900-m circumference and a 350-mA circulating electron current. Three different x-ray spectra would be provided to users. Synchrotron spectra are specified by λ_c, the wavelength at which half the radiation lies above and half below. One spectrum is emitted from within the bending magnets, which hold the electron beam in circular orbit. This radiation would be available at 10 to 20 ports with 20 to 40 experimental stations, and would be characterized by λ_c = 2 angstroms, with a $\Delta\theta$ = 10 mrad angular spread from each port. Multipole wigglers with λ_c = 1 angstrom and $\Delta\theta$ = 2 mrad would feed 28 to 42 ports, and 1-period spectrum shifters with λ_c = 0.25 angstrom and $\Delta\theta$ = 12 mrad would provide radiation to as many as 10 ports with three stations each. In addition to the high beam energy, a major selling point of the proposed device is a small beam diameter (0.17 mm as compared with 0.4 mm for Brookhaven or 2.7 mm for Daresbury). As brightness scales inversely with the beam cross-sectional area and the three machines have comparable electron currents, ESRF should provide orders-of-magnitude higher brightness than the other dedicated facilities. The high brightness does not depend on advanced

technology because, for example, the venerable 3.5 to 5.6-GeV DORIS synchrotron in Hamburg could meet the performance of ESRF if it were dedicated as a photon source.

Siting of ESRF and support facilities at Risø is estimated at 120 million ECU (European Currency Units, approximately equal in value to the dollar), with experiments beginning 6 years after the start of construction. The cost is comparable to that of the smaller Advanced Light Source for ultraviolet and soft x-ray radiation to be built at the Lawrence Berkeley Laboratory. The proposed design places the injector accelerator and all facilities necessary to run the storage ring within its circumference. All laboratories and offices connected with experiments will be on the outer circumference of the experimental hall. The facility is designed to provide about 100 stations during the first phase of operation and will employ about 2,000 people each year in experiments and operation.

In support of Dr. Buras' comments, an illustrated booklet entitled "ESRF at Risø" was distributed to all conference participants. The booklet outlined the siting proposal and described the advantages of the Risø location. The point was made that a facility for condensed matter research benefits if a research reactor is nearby (as is the case at Brookhaven)--neutron beam probing of matter supplements information from x-ray measurements. The 10-MW DR3 reactor is the largest experimental facility at Risø and, with eight beam tubes tangential to the reactor core, is well suited to neutron diffraction experiments. It remains competitive with high flux reactors for condensed matter research because of a 35°K hydrogen moderator, which increases the neutron flux by an order of magnitude.

Further information on the Risø siting proposal is available from the Library, Risø National Laboratory, DK-4000 Riskilde, Denmark. The full feasibility study for ESRF is available from the ESF, 1, Quai Lezay-Marnesia, F-67000, Strasbourg, France.

T. Moskey

NEW DIRECTIONS FOR PHYSICS RESEARCH IN GREECE

A minor revolution in scientific teaching and research is under way in Greece. The impetus is an education law passed by the national government last year. The legislation democratizes university administration and provides for upgraded teaching laboratories. Increased support is granted for areas of applied research that can be established with modest resources, that provide opportunities for high quality scientific contributions, and that are attractive to high technology industries. Another objective of the legislation is the development of US-style graduate education programs. With these steps, the national government hopes to train and employ Greek scientists otherwise lost to universities and laboratories abroad.

My recent visits to centers for physics research at the Univ. of Crete in Iraklion, the Nuclear Research Center Demokritos, the National Technical Univ. (NTU) in Athens, and a second campus of NTU in Zografu have indicated how the new law has affected research. This article presents a few general observations arising from discussions with physicists and then reviews research efforts at individual institutions.

Background

The most striking fact was that about three-fourths of the scientists received their graduate training in the US. Indeed, several of the physicists I spoke to had worked under ONR contracts at American universities. The rest received their doctoral degrees from universities in the UK, France, or West Germany. Training and research opportunities abroad have led to a "brain drain" of good scientists.

Cooperative research efforts are frequently established between scientists in Greece and the European universities at which they studied. Although most scientists were trained in the US, I spoke with only one currently engaged in research performed jointly with an American institution. Cooperation and exchanges with Eastern Bloc countries are increasing because these countries have research programs on a scale similar to Greece and share similar developmental problems. Also, their proximity makes exchanges of personnel and equipment convenient and economical.

A new Ministry of Science and Technology has been established to direct the national research effort. Both the ministry and scientists have a realistic approach to the research that can be done with limited resources. The institutions I visited are stressing condensed matter research with small scale facilities that can provide important contributions to physics with many industrial applications. In

addition to research laboratories, universities have well-equipped student laboratories for electricity, electronics, and electro-optics.

Before the new law, chairs of science had been held by senior scientists for indefinite periods. The legislation replaces chairs with a departmental structure composed of research teams and provides for the popular election of department heads. I was surprised to learn that department heads and even the university presidents were (or were soon to be) elected by faculty and students--each group with a 50% share of votes. Researchers felt satisfied with the process--student demands for a say in their education were met, while people already elected to leadership were well qualified. (The highly political mood of undergraduate students in Greece today is similar to that in the US in the late sixties. One difference is that the various student factions are aligned with political parties and take positions on national and international issues.)

Finally, the high levels of expertise and enthusiasm displayed by the scientists were impressive. In response to ministry objectives, many scientists are being directed into new research areas and are responsible for creating new facilities. University scientists are hampered in their research efforts by a shortage of support staff such as machinists, electronic repair personnel, computer operators, and librarians. Many researchers do such jobs for themselves and their associates. Participation in support activities was particularly strong at the Univ. of Crete, a new university and the site of the first model graduate program. Research personnel must reassemble laboratories, act as librarians, assemble and run a computer system, and install and maintain a new helium liquefier. The Nuclear Research Center Demokritos was the one institution visited that did not appear to suffer from support staff shortages. Demokritos' facilities for machining and electronics fabrication supplied not only their own departments, but also universities.

NTU, Athens

The Electrical Engineering Department of NTU performs theoretical electro-physics research applied to problems of microwave and light communication, remote sensing, and microwave electronics. Drs. P. Seraphim and J.D. Kanellopoulos described the department's work in antenna theory, scattering of electromagnetic (EM) waves, microwave propagation in rain, and EM wave propagation in dielectric waveguides and fibers.

The effects of rain on the atmospheric propagation of microwaves has been studied for the past few years in a joint project with Imperial College (London)--a continuation of Kanellopoulos' graduate research. Recent research involves the cross-polarization and depolarization of satellite and terrestrial signals in systems using orthogonal polarization of two carriers. Orthogonal polarization permits two independent communications links for each operating frequency but requires a high degree of isolation between the two polarizations. Rain, as a principal agent in atmospheric cross-polarization and depolarization, causes periods of radio signal outage. A statistical, numerical technique has been developed to predict polarization interference effects. The technique divides the signal path into incremental slabs, within which single scattering events can be assumed. Numerical and theoretical results provide good agreement when compared with experimental data from the eastern US and southern England. Results demonstrate that information concerning the rate and angle of rainfall, the microwave frequency, path length, and size distribution of raindrops can be used to determine precisely the outage time of communication systems. The objective of related research is to develop algorithms to determine the best microwave path for given weather conditions when many alternatives are possible.

Communications applications are also stressed in research related to asymmetric optical fibers and inhomogeneous dielectric waveguides. The symmetric core and cladding modes of an eccentrically cladded three-layer waveguide have been examined, and the perturbation in the cutoff wave number due to the asymmetry has been determined. Scattering from cylindrical inhomogeneities inside a slab waveguide has been investigated analytically using Green's function techniques. The problem is of interest to the development of integrated optics because such inhomogeneities can be used to develop circuit elements such as filters, mode couplers, and cavities. Undesirable scattering effects can also occur at material defects or at the junction of two dielectrics.

Green's function solutions were also used to determine the radiation field of an arbitrarily oriented dipole in the presence of a grounded gyromagnetic slab. The properties of electro-

magnetic fields in gyromagnetic media must be determined to develop nonreciprocal microwave devices using printed circuit (microstrip) elements. Once the Green's function is known for a given microstrip geometry, the integral equation solutions specify the device's radiation properties, such as the variation with applied magnetic field.

Separation of variable and Green's function techniques have been applied to scattering of plane waves from eccentrically coated metal spheres and cylinders, and from underground tunnels. Solutions apply to the detection and characterization of radar targets, underground pipes, and other buried structures. Prior to experiments, it is useful to have theoretical information about the scattered fields so that signals from the object can be educted from the highly cluttered ground return signal. Although not an objective of NTU's work, the techniques and results of such research can be used to determine the electromagnetic pulse (EMP) response of underground structures.

NTU, Zografu Campus

The physics department at the Zografu Campus concentrates on condensed matter and nuclear physics. The condensed matter projects of the Physics Laboratory III were described by Dr. E. Anastassakis, its director. Resonance enhanced scattering of far infrared radiation and Raman spectroscopy are used to investigate the lattice dynamics, electronics, and phonon properties of advanced semiconducting materials. Such measurements have been used to study the temperature distribution on a silicon surface produced by continuous (CW) laser irradiation. It is important that the irradiation be CW to emulate industrial processes. Joint research with the Physics Institute of the Univ. of Aachen, FRG, concentrates on the properties of the compound semiconductors alpha tellurium iodide (α-TeI) and thalium antimony sulphide ($TlSbS_2$). The first compound belongs to a class of newly grown semiconductors with solar cell and computer memory applications. The second may be used for infrared filter and bandpass windows. Laboratory equipment for condensed matter studies includes argon and krypton ion lasers and a dye laser to provide both probe and heating beams in the green and red, and a double grating spectrometer photomultiplier combination for phonon-coupled spectrum measurements in the 3,500-angstrom to 1-μm range. Exchange of materials and personnel with Czechoslovakia and Bulgaria for research on these topics is beginning.

Currently, the shape of the Raman Stokes line from lanthanum fluoride crystals is being investigated as a means of measuring the variation of temperature across a crystal locally heated by focused laser light. The technique relies on the temperature dependence of the Stokes frequency. Contributions from different temperature regimes produce a single, wide sum line with distinctively asymmetric wings. The line measurement is straightforward, but algorithms must be developed to unfold a temperature distribution from the line shape. It is hoped to apply the measurement technique in industry, where the temperature distribution must be monitored to control thermal processing and to prevent excess strain due to thermal gradients. Other ongoing condensed matter research involves the interactions of ultrasonic waves with liquids and the effects of microwaves on biological tissues.

Nuclear physics research is conducted at Zografu in collaboration with Demokritos, and high energy physics research supports the NA14 detector on the Super Proton Synchrotron at the European Center for Nuclear Research (CERN). Dr. A.C. Xenoulis described the nuclear work in the areas of compound nuclear emissions, p-p and p-n excited gamma ray spectra of ^{121}Te, and neutron reactions in metals. The neutron reaction work, sponsored by the International Atomic Energy Agency, is of practical interest because metal structures in fission and fusion reactors will be subject to high neutron fluxes. Neutrons are produced for the study of n-d and n-α reactions in iron and copper from d-d reactions using the tandem accelerator at Demokritos.

Univ. of Crete

The Univ. of Crete in Iraklion occupies a unique position in that it has been designated as the first institution that will offer a US-style doctoral program. The Ministry of Science and Technology has granted substantial funds to achieve the objective. Scientists are being recruited to teach and to establish experimental facilities that can support competitive graduate research. The exciting prospect of helping to shape the new graduate department has drawn scientists back to Greece from established careers abroad.

The Laboratory of Electrical Discharges, created in 1980, is the first advanced research laboratory established at the Univ. of Crete. Dr. D. Karabourniotis, the laboratory director, said the purpose of the

research is to develop spectroscopic methods for diagnosis of optically thick plasmas within high intensity arc lamps. The study of high-pressure mercury discharges is of particular interest because of applications of these intense ultraviolet sources to photon-induced surface chemistry, polymerization, and microlithography.

To achieve the high ultraviolet intensity required for industrial processing, discharges must be established in high pressure media. However, at high densities, radiation reabsorption in the plasma is strong. Unfolding the plasma density and temperature profiles from spectroscopic scans across the discharge is therefore a difficult procedure when compared to the optically thin discharges encountered in lower intensity lamps. Karabourniotis and coworkers are making detailed measurements of line spectra and individual line shapes which, in conjunction with arc and radiation transport models, can be used to infer plasma profiles. The research is aimed at the design of optimized arc lamps with specialized emission spectra for particular industrial applications.

Research at the laboratory is a continuation of Karabourniotis' thesis work at the Univ. of Toulouse, France, with which there is ongoing close collaboration. Recent joint project results include: (1) the development of techniques to determine pressure and temperature in mercury discharges from measurements of self-reversed spectral lines (i.e., those with strongly absorbed line centers), and (2) an analysis of the emission effects produced by plasma discharge modulation at the 50-Hz electric line frequency. Principal measuring instruments include a computer-compatible monochrometer with 300 and 2,400 lines/mm holographic gratings, a spectral scanning control unit with synchronized recorder, an optical pyrometer, an infrared thermometer, and an optical multichannel analyzer (OMA). The Ministry of Research and Technology has provided funds for the purchase of new equipment which will allow instantaneous measurements with the OMA. Other faculty members involved with the research effort are P. Lambropoulos, a specialist in atomic physics, and N. Flytzanis, who is involved in plasma arc modeling. Future research will concentrate on problems associated with arc lamps composed of mixtures of metal and metal halide vapors. Additives to the basic mercury vapor provide unique spectral features geared to specific industrial applications.

Other research facilities in the physics department are being assembled following the university's recent move to new quarters. Laser and cryogenic facilities are being made ready for solid state experiments. (The helium liquefier facility provided by the ministry for this work will be the only one in Greece.) Flytzanis and L. Ikonomo, the department chairman, are developing theoretical models for the dynamics and electronics of amorphous silicon semiconductors. Since this material can be used for inexpensive solar cell fabrication, the physics department's theoretical work lays the foundation for future condensed matter experiments at the Univ. of Crete. Related work by Flytzanis concerning solitons in diatomic chains was reported in ESN 36-10: 267 (1982).

Nuclear Research Center Demokritos

The Nuclear Research Center Demokritos at Aghia Paraskevi, a suburb of Athens, carries on broad-based applied nuclear research in divisions devoted to electronics, biology, chemistry, physics, health physics, reactors, radioisotopes, environmental radioactivity, and soil science. I spoke with senior scientists in the electronics and physics divisions about a variety of research projects.

The Physics Division contains three condensed matter research laboratories based on Mössbauer spectroscopy, thermoluminescence techniques, and x-ray analysis. S.E. Filippakis, the director of the x-ray laboratory, described the use of x-ray diffraction and spectroscopy to study the optical properties of x-radiation in crystals, crystal structure, organic molecules, corrosion chemistry, and archaeometry. Laboratory equipment for the efforts includes a Syntex defractometer, energy dispersive and wavelength dispersive fluorescence spectrometers. X-ray fluorescence (XRF) spectrometry is a method for the qualitative and quantitative determination of elemental composition based on the detection of externally excited characteristic x-rays. In energy-dispersive XRF, radiation from all elements is detected simultaneously, then sorted electronically.

After samples are cooled to liquid nitrogen temperature, diffraction analysis is used to determine the crystal structure of small (molecular weight ≤800) organic molecules with pharmacological applications. X-ray diffraction is also used to study cement corrosion in support structures (particularly bridges)--corrosion caused by the

interaction of aluminum silicates with atmospheric SO_2.

Both diffraction and x-ray fluorescence techniques are used for archaeometric analyses of artifacts from ancient Greek cultural centers; the procedures help in dating and in determining the location and techniques of manufacture. Wavelength dispersive spectroscopy can find trace elements with atomic numbers greater than 20 to about 20 ppm concentrations in fresco pigments, pottery, obsidians, amber, bronzes, lead, and silver. Thus, scientists can locate the source of the materials and determine the technological connections between different sites. Energy dispersive techniques allow element identification for any atomic number down to about 100 ppb, and microscopic mineralogy is used for confirmation of spectroscopic results. The x-ray laboratory also uses trace element analysis for identifying geological samples and measuring environmental pollution. In the area of solid state physics, the optical properties of x-rays in crystals are studied. Current work includes measurements of anomalous dispersion in silicon crystals in the 20 to 300°K regime.

Y. Maniatis and A. Kostikas of the solid state spectroscopy group carry on archaeometry research by taking Mössbauer spectra of ancient pottery. The energy of emitted γ-rays from ^{57}Co (the parent nucleus of ^{57}Fe) is modulated by imparting an oscillatory motion to the source. When the γ-ray transmission through the sample is plotted against the source velocity, resonant absorption is observed due to hyperfine splitting of ^{57}Fe nuclei in the clay. Information about the origin and firing of the clay is acquired by determining the contributions of the ferric, ferrous, and magnetic iron oxide phases to the spectrum. Zeeman splitting (due to immersion of the sample in a magnetic field) and cryogenic cooling are used to enhance various components of the Mössbauer spectra. Kostikas also uses Mössbauer techniques to study the chemical bonding and magnetic properties of iron complexes in aprotic solvents and proteins.

In addition to fabricating and maintaining laboratory equipment, the electronics division researches computerized data acquisition and processing. Dr. Konstantine Laskaris said the current areas of interest are cryptography, medical electronics, and signal processing. The group is developing software for ultrasonic acoustic tomography. Unlike tomography with x-rays, the acoustic probe beam is refracted by passage through various body tissues. The bent body path complicates the unfolding of probe beam path integrals to give a cross-section of body tissues. The problem is being approached by computer simulation of beam paths through simple geometric structures. By developing unfolding algorithms for these, it is hoped to gain insight into a general procedure for human body probing. A sound frequency of 100 kHz is used for the calculations and will form the basis for future experiments. Laskaris and coworkers are also developing image processing techniques using microprocessors for two-dimensional spatial filtering in image processing.

Research in plasma physics at Demokritos has centered on theoretical and experimental investigations of drift wave instabilities in a microwave excited, magnetized, argon discharge. The presence of drift waves leads to enhanced losses in magnetically confined thermonuclear plasmas so that the experiment is relevant to the European fusion effort. As radio frequency (rf) heating will be used in the Joint European Torus (Culham Laboratory, Abington, UK), low-frequency drift waves driven by rf heating are of particular interest.

An argon plasma with ionization in the 0.1 to 1% range is excited within a coaxial microwave cavity by a 2.45-GHz magnetron with 20- to 120-W power. Langmuir probes sampling the 6-cm diameter plasma at different radii and azimuths provide time-averaged radial profiles and drift wave fluctuations of plasma density and potential. Measurements were performed with fill pressures varying from 1×10^{-5} to 5×10^{-4} Torr and plasma densities in the 10^9 cm^{-3} regime. The axial magnetic field was varied about 875 G. At this resonant value, B_o, the microwave frequency corresponds to the electron plasma frequency, so strong changes in rf coupling can be achieved with small excursions of the magnetic field. Below B_o, the drift wave grows at large radius, where the time averaged density and potential profiles have negative slopes. Above B_o, the wave grows at smaller radius, where both profiles have positive gradients. As required by theory, the wave reverses azimuthal phase (i.e., propagates in the opposite rotary sense) as the field passes through B_o.

Dr. A. Anastassiades and a coworker analyzed the results with linearized two-species, fluid-drift equations into

which the time-averaged gradients were imposed. The resulting dispersion relation for the drift wave spectrum is in good agreement with the experiment and demonstrates the importance of electron drifts induced by rf-heating fields.

The Plasma Laboratory has been encouraged by the national government to take an active role in European Economic Community fusion programs. Recently, a cooperative effort has been established with the ASDEX Tokamak group at the Max Planck Institute for Plasma Physics (Garching, FRG). Anastassiades, the laboratory director, mentioned that his group will assist ASDEX with diagnostic development and that funds have been allocated for an exchange of scientists between the two organizations.

F. Mosher

STATISTICS

ENVIRONMENTAL EXTREMES MEETING

"Statistical Modeling of Extreme Events" was held at Imperial College (UK) on 11 April 1983. It was organized jointly by the Department of Mathematics at Imperial College and the Institute of Hydrology (Wallingford, UK). Roughly one quarter of the approximately 100 participants were statisticians; the rest came from disciplines such as civil engineering, oceanography, and meteorology, and from organizations such as water authorities, power companies, railroads, and insurance companies.

The conference concerned modeling environmental extreme events such as river flows (flood, drought), climatic conditions (rain, wind), and sea conditions (waves, tides). Modeling problems often occur when the main requirement is to estimate how often an event of a given size will take place. For example, a civil engineer must consider loading on a building due to winds, and in particular the peak, or extreme, loading (and hence wind velocity) that might occur in the next 50 or 100 years. Or the engineer might wish to estimate how often wind loading will exceed a value used in determining building design specifications. Six major presentations were made at the conference; they covered both practical applications and current theoretical work, and substantial periods were set aside for discussion and questions.

Dr. Max Beran (Institute of Hydrology, Wallingford, UK) presented a paper on "Extreme Value Problems and Solutions in Hydrology," in which he described some methods hydrologists use and touched on a few problems encountered in hydrology that will require further research by statisticians. To improve their estimates of extreme river flows, hydrologists are attempting to use covariate information--usually estimates of the 99th percentile of the distribution of maximum annual river flow, which they call the "100-year recurrence time." For example, variables such as catchment size, soil type and wetness, and topography of the catchment are related to river flow resulting from rainfall. The most commonly used method of incorporating such covariables is to regress mean flow on them and to use a fitted distribution with the mean to estimate extremes. Beran pointed out that current practice in hydrology concentrates on modeling with only maximal and minimal flow data, but there is useful information in all flow data, so perhaps a time series approach should be used. He also mentioned that hydrologists need better methods for sampling "dependent data," such as with time series exhibiting serial and spatial correlation. Beran commented that there is a need for modeling the underlying processes, rather than merely fitting distributions and estimating parameters.

In a review of models for extremes, Dr. C.W. Anderson (Univ. of Sheffield, UK) discussed classical theory and dependent sequences. Classical theory is concerned with the analysis of relative extremes in a sequence of independent, identically distributed random variables. Results due to Gnedenko and Gumbel show that as the length of the sequence becomes large, there are only three possible limiting distribution forms for the largest observation in such sequences. The rate of convergence to the appropriate limiting distribution depends on the parent distribution for the random variables in the sequence. For example, the rate is proportional to 1/log n for a normal parent and is proportional to 1/n for an exponential parent. The rate of convergence may be slow; Anderson suggests using normalizations other than the Gnedenko-Gumbel linear forms, which may give limit forms with faster convergence. Appropriate transformations of the data might also speed convergence, according to Anderson. He said that using a distribution other than one of the three limit forms, and with more parameters, can improve the fit in practical applications.

In the second part of his paper, Anderson considered stationary sequences of random variables that are not necessarily independent. Under appropriate conditions of "independence" of variables far apart in the series, the three limit distributions of classical theory are again encountered. The point process of extremes above a threshold ("exceedances") approaches a Poisson process under fairly general conditions. With stronger serial correlation in the sequence, the process gives clusters of exceedances in which the "cluster positions" approach a Poisson process. Anderson believes that such point process models have promise for use in a variety of applications. At the end of his talk, Anderson sounded a note of caution about the lack of robustness of many of the extreme value theory results.

Dr. T.A. Buishand (Royal Netherlands Meterological Institute) described his work on estimating high return period rainfall amounts. He is concerned with questions such as "how often will a 100-mm rainfall occur [somewhere in the Netherlands]?" The answer involves extreme values in two dimensions, time and station. Buishand treats records as multivariate over stations, with independence between years. This led him to consider multivariate Gumbel distributions for modeling maximum rainfalls. For example, a bivariate Gumbel distribution function is of the form $\exp[-(e^{-x}+e^{-y})\cdot h(y-x)]$, where h is the "dependence function." Buishand discussed methods of estimating the "dependence parameters" in an assumed form of h, and showed examples applying the model to 10 years of data from 140 stations in the Netherlands.

Dr. J.R. Mayne (Building Research Establishment, Garston, UK) presented a paper entitled "On the Estimation of Extreme Wind Loads." Current trends in engineering and building practice are leading to structures that are more sensitive to wind. Present building codes in the UK require structures to withstand the "peak 50-year gust" at mean atmospheric pressure. Current research concerns how buildings should be designed to meet this code. The power spectral density of the wind time series has two peaks, one at a period of about 4 days and one at a period of about 1 minute. The lower frequency events are associated with general weather features, such as low pressure regions, while the higher frequency peak is associated with local features, notably wind gusts. Mayne and his group have modeled these phenomena separately, and have combined them in a model that gives wind loading distribution as a function of atmospheric pressure and wind velocity component distributions. Mayne is now working on analyses of wind directions in various locations and on the implications for building codes.

A similar approach was reported by D.T. Pugh and J.M. Vassie (Institute of Oceanographic Sciences, Bidston, UK). Pugh and Vassie are concerned with the safety of offshore platform structures, particularly the response of platforms to the combined effects of wind, waves, currents, and surges. The sea level at a given time is the sum of components such as mean sea level, tide, surge, and the interaction of tide and surge. The components are modeled separately, and convolutions are used to obtain the distribution of sea levels. An interesting application is to the tension leg platform. Its legs are anchored at the sea bottom, and the buoyancy of the platform legs and substructure puts the legs under tension. For such a platform, the most dangerous condition is when there are high waves and low sea level. Thus, Pugh and Vassie want to be able to estimate the return periods of a variety of low sea level and high sea state conditions.

The final paper of the day, "Statistical Inference for Extremes," was by Dr. R.L. Smith (Imperial College, UK). Smith described a "generalized extreme value distribution," which includes three Gumbel-type distributions. For the mean parameter, he included a linear model that involved known covariates and unknown parameters. The method has some advantages over the classical Gumbel approach: the choice of an explicit Gumbel-type distribution is avoided, and there is a more stable parameterization, which facilitates statistical methods such as maximum likelihood estimation. Smith described applications to testing for linear trend in a data set of annual minimum temperatures covering 50 years. He has also applied such methods to world records in running the mile and described how he estimated the medians of the extreme value distributions for future years. Smith mentioned that much additional work is needed on graphical methods, diagnostics, conditional inference procedures, and multivariate extremes.

The conference was unusual in that it brought together researchers from a wide variety of applications areas as well as statisticians. It is clear that in the UK there is great interest in extreme value theory and associated statistical methods. Perhaps the most exciting work is that associated with

multivariate extreme values and stochastic process models.

D.R. Barr

NEWS & NOTES

RESEARCH WILL SUPPORT FLEET DURING MOBILIZATION

How can US Navy laboratories give the fleet rapid support during wartime? The Office of Naval Research (ONR) and Naval Research Laboratory's (NRL) International Technology Exchange Program may be the answer.

Sponsored by RADM L.S. Kollmorgen, Chief of Naval Research, the exchange program draws on the technical skills of 19 Naval Reserve officers. There are three five-man teams--one specializing in antisubmarine warfare, another in air and surface warfare, and the third in space and surveillance systems. Depending on the Navy's needs during mobilization, one or more of the teams would be sent to ONR, London. There, the officers would provide a direct link between US Navy and NATO commanders in the area and NRL, where four other reserve officers would be coordinating the wartime technology exchange program.

The goal of the London teams is to let NRL know about the needs of the fleet during mobilization and thus to draw upon the expertise of some 3,000 scientists, engineers, and technicians. The Navy would be using NRL's talents to the fullest--from fundamental research to design and fabrication. Although NRL usually does long-term, basic research, the laboratory would be called upon to support the fleet quickly during hostilities. NRL's research skills would be brought to bear not on projects lasting years, but on the immediate problems of the first c itical 30, 60, or 90 days of mobilization.

For example, the London team might learn that a NATO destroyer in the North Sea has to have a unique-application operational transceiver; NRL could design the device, build it, and send it out with the team. Or NRL might design the device and send the plans to the UK; the London team, using its contacts with the UK's Ministry of Defence and British industry, could have the device made and sent to the ship.

To achieve the rapid response that is so vital, the reserve officers must keep abreast of European scientific research and identify key personnel in industry and universities. Therefore, one team spends 2 weeks each year at ONR, London. So that they will be prepared to get their jobs done quickly and effectively during mobilization, the teams use the 2-week training periods to learn how to establish contracts with the British and how to cooperate with government agencies overseas.

CAPT R.A. Tremant, Director, Allied Technology Exchange, was recently in London with the air and surface warfare team. According to Tremant, the exchange program is valuable because it allows the reserve officers to work with the UK's Ministry of Defence and to examine trends in industrial and university research. He said, "We're establishing and maintaining the know-how so critical to an effective technical link allowing NRL to take on a rapid-response role not normally filled by research facilities and research personnel."

A similar ONR reserve program concentrates on technology exchange within the US. Members of the University/Industrial Field Teams work with industries and universities just as the International Technology Exchange participants do overseas.

L.E. Shaffer

SOVIET MEDICAL RESEARCH

Several medical advances have been noted recently in Soviet newspapers and journals. When standard "Hela" cells were exposed to a helium-neon laser, twice as much DNA was synthesized in the irradiated cells as in control cells. While investigating the importance of the coherence of the light radiation, the Russian investigators discovered that "plain" red light (light from a white projector bulb passed through a red filter) also had biological effects. Clinical studies of 165 ulcer patients at the Gorky Medical Institute suggested that both laser and red-light treatments are highly effective in promoting healing.

The USSR Academy of Medical Sciences reports the development and mass production of vaccine for the prevention of tick-borne encephalitis. While few details were furnished, the Institute of Poliomyelitis and Virus Encephalitides was responsible for the research and chromatographic production methods. (More detailed effectiveness studies, say in comparing the Russian vaccine

with the Austrian vaccine now well known in the West, might be desirable.)

The Soviet All-Union Scientific Research Institute of Work Safety claims to have produced an ear-protective device that screens out or reduces non-speech noise but leaves much of the speech signal intact. Several ear defenders produced in the US can attenuate non-speech sounds but usually make speech nearly unintelligible. Western safety specialists probably will be interested in the performance of people wearing the Soviet "anti-noise" device.

Specific sources of the above claims appear in the *Soviet News Abstract Publication* for April 12, April 8, and April 15, respectively.

N.A. Bond, Jr.

BEHAVIORAL CHANGES IN HOUSE PAINTERS EXPOSED TO SOLVENTS

Many organic solvents are neurotoxic if inhaled in heavy doses; several studies have shown that car and industrial spray painters may suffer adverse effects with long-term exposure. At the Institute of Occupational Health in Helsinki, Finland, Karl Lindström recently tested a group of 219 experienced house painters on some standard psychological measures. The painters had an average exposure time of 22.5 years, and their typical 8-hour "white-spirit" exposure was estimated to be 40 ppm. As a matched but nonexposed comparison group, 229 concrete reinforcement workers were selected so that their pre-exposure intellectual level statistics were the same (matching data were obtained from the Finnish Army's testing records).

Figure 1 shows that the long-term house painters had lower visual reproduction scores (the test was from the Wechsler Memory Scale); they also had higher simple reaction times than their matched controls in the nonexposed sample. The subject-matching procedure indicates that the behavioral effects of paint exposure, though perhaps slight, were still discernible and statistically significant. The exposure the men experienced was considerably below the hygienic limits established by Finnish health authorities; auto spray painters showed much greater deficits. Fortunately for people in the painting industry, the present water-based paints are believed to be far less neurotoxic, so the next generation of house painters

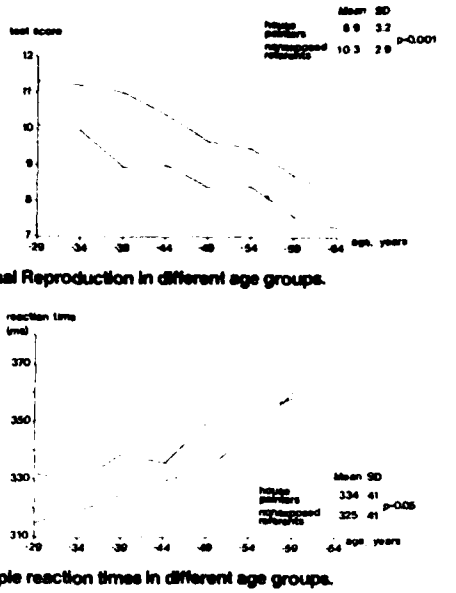

Figure 1. Visual reproduction and simple reaction times.

should not experience the same solvent-based deficits as the group evaluated here.

N.A. Bond, Jr.

HOLOGRAM PRINTER

Applied Holographics, a new UK technology firm, has announced a process for rapid and economical printing of holograms. Reportedly, a pulsed-laser beam will pass through an original hologram and be registered on sensitized 30-cm × 40-cm sheets, which move along at the rate of some 3,000 per hour. If production quality reaches the levels achieved in experimental runs, cheap "true holograms" can be delivered. The printing machine reportedly costs about $150,000.

The firm claims to have solved most of the grating and registration problems associated with mass-produced holograms. Some demonstration test sheets give an impressive three-dimensional effect when viewed in ordinary light. Many applications can be foreseen if cheap holograms can really be provided. For security purposes, an object can be marked so that the numbers can be read only in a certain holographic orientation. As

advertising novelties, hologram displays might have an arresting impact on the viewer. There are also some training and simulator possibilities, such as displays for showing the operation of complex physical systems.

N.A. Bond, Jr.

FAST PEDESTRIAN WALKWAY IN PARIS

The moving sidewalks in big airports go quite slowly (<1 m/s), primarily because at higher speeds pedestrians might have trouble getting off and on. In fact, a few people are thrown off their feet every day on the moving walkways at Heathrow Airport in London. A new French "TRAX" system operates at much higher speeds (3.3 m/s) in the middle part of the walkway, but more slowly at each end. The initial Paris installation will be 175 m long, and should be running next year; it will connect a Metro underground station with a railway stop.

A system of overlapping plates is the key design feature; the plates overlap less in the middle of the walkway, and the degree of overlap is controlled by subsurface guide units. When the track runs over certain key points, the overlap is reduced or increased, thus resulting in walkway acceleration or deceleration. Reportedly, many safety tests will be run before the system opens. If such fast-moving walkways turn out to be safely and economically operated at the claimed 12 km/hr, they might be popular for links in high-density office and shopping areas. Incidentally, TRAX is being produced by a subsidiary of Alsthom Atlantique, manufacturer of the "Train Gran Vitesse," which at 260 km/hr is the fastest train in the world (*ESN* 35-10:404-405 [1981]).

N.A. Bond, Jr.

ATOM-PROBE (FIELD ION MICROSCOPY) AT CAMBRIDGE

A visit to Prof. R.W.K. Honeycombe, FRS, Goldsmiths' Professor of Metallurgy, Department of Metallurgy and Materials Science, Univ. of Cambridge, led to a discussion of current studies of engineering materials using modern atom-probe techniques derived from the field ion microscope. (See *ESN* 36-10:272 [1982], *ESN* 37-2:69-71, 83-84 [1983], and *ESN* 37-3:105-111 [1983] for research activities at Göttingen and Oxford). Recently, S.S. Brenner and M.K. Miller (1983) have reported on methods of atomic scale analysis based on the atom-probe and described metallurgical applications accomplished at the U.S. Steel Corporation, Pittsburgh. Previously, Miller was at Oxford. Sir Alan H. Cottrell, FRS, had promoted the activity at Cambridge for metallurgy and materials science applications in 1959--even before Honeycombe succeeded him in 1966. Persons such as D.G. Brandon, M.J. Southon, B. Ralph, and S. Ranganathan did their early work on the subject at Cambridge. Ralph and Southon have continued the activity with colleagues and students. Figure 1 shows the Cambridge system described recently by Ralph, Hill, Southon, Thomas, and Waugh (1982).

Current applications of the atom-probe technique at Cambridge include surface studies relating to oxidation and modified surface compositions of alloys, and bulk studies relating to phase separations, such as in nickel-aluminum superalloy materials (Hill and Ralph, 1982). In the latter case, the spinodal decomposition of a nickel-14.1 atomic percent aluminum alloy at 900°K has been studied with the atom-probe to show that cellular decomposition of phases occurs at grain boundaries and that a smooth transition to conventional nucleation and growth of the equilibrium phases occurred as the alloy quenching rates were lowered. The thermodynamic supersaturation is a critical factor in determining subsequent events, as expected.

References

Brenner, S.S. and M.K. Miller, "Atomic Scale Analysis With the Atom-Probe," *Journal of Metals*, 35,3 (1983), 54-62.

Hill, S.A. and B. Ralph, "Continuous Phase Separation in a Nickel-Aluminum Alloy," *Acta Metallurgica*, 30 (1982), 2219-2225.

Ralph, B., S.A. Hill, M.J. Southon, M.P. Thomas, and A.R. Waugh, "The Investigation of Engineering Materials Using Atom-Probe Techniques," *Ultramicroscopy*, 8 (1982), 361-376.

R. W. Armstrong

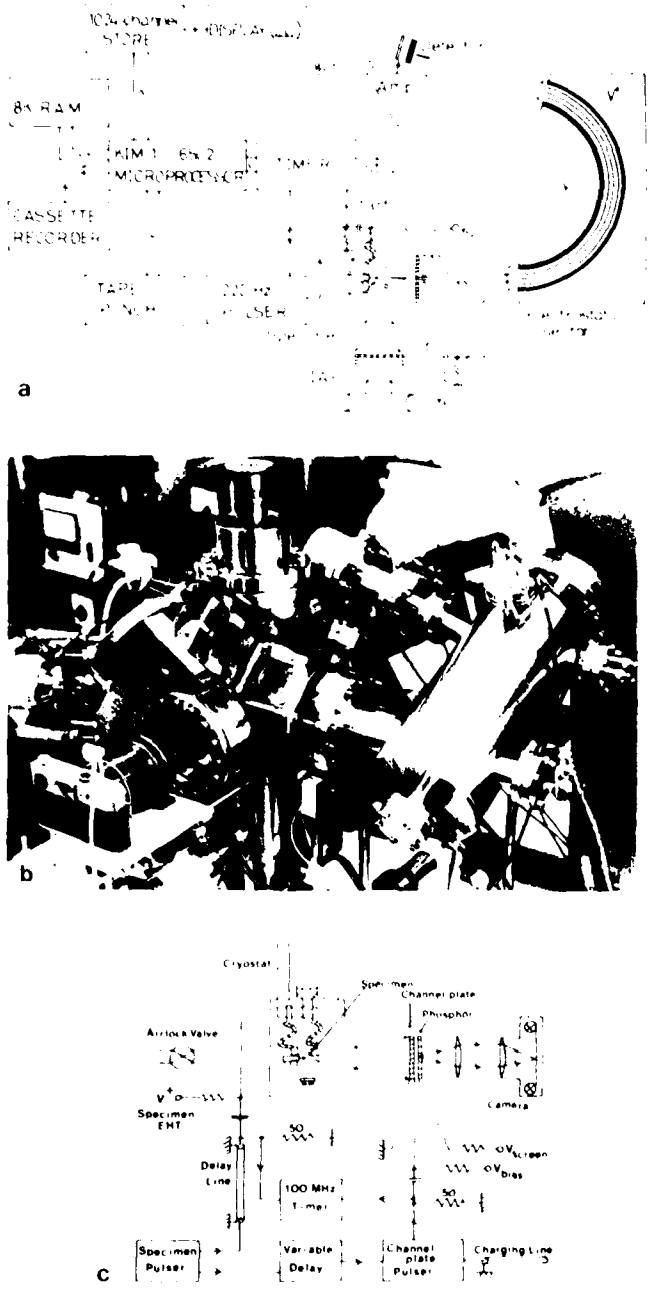

Figure 1. (a) schematic diagram of atom-probe system incorporating an energy-compensated spectrometer; (b) photograph of the instrument; and (c) analysis system involving a channel plate image intensifier for selected atomic spectroscopy.

UK/US MARITIME AND MARINE COMBAT CASUALTY CARE WORKSHOP

From 25 through 27 April 1983, the US Navy and the UK's Royal Navy convened a workshop on medical operational problems in cold environments. Topics included resuscitation of cold victims, exercise and fluid management, vascular and neurological effects of cold, and equipment and clothing requirements for protecting individuals from hypothermia.

Many examples were given of injuries sustained during maneuvers in the cold, and descriptions of the casualties due to cold in the Falklands campaign received much attention. Preliminary information indicates that the near-freezing temperature, high winds, and heavy rains in the Falkland Islands caused disabling nonfreezing injuries of the feet (trench foot) in many soldiers.

CAPT C.R. Valeri (Naval Blood Research Laboratory, US) discussed cardiac irritability in animal models of hypothermia and pointed out that citrated plasma can induce cardiac irritability and electromechanical dissociation. Bleeding time was prolonged due to dysfunctional platelets. Observations made using a model of hypothermic-hypovolemic shock suggested that the victim of hypothermia should be rewarmed before fluid resuscitation is begun.

Blunting of the vasodilatory response in the fingers after cold injury was shown graphically in data taken by Surg. Lt. Cdr. D.I. Riddell (Royal Marines, Deal). Normally, a hand held in ice water drops to a low stable temperature until perfusion to the skin begins to increase and the hand becomes warmer. After frostbite injury, however, this secondary warming response is lost and the hand remains cold. More than 5 months may be required for complete recovery.

Surg. Cdr. F. St. C. Golden (Institute of Naval Medicine, Alverstoke) reviewed data obtained thus far from the Falklands campaign. In particular, it was pointed out that the excitement of battle may lead to greater peripheral vasoconstriction because of catecholamine release, and that this in turn can extend the vasoconstriction and reduce blood flow even further. Golden suggested possible treatment that would block sympathetic nervous system activity pharmacologically to prevent further vasoconstriction.

Surg. Cdr. J.M. Beeley (Royal Navy Hospital, Haslar) described exercise in cold environments, mentioning that susceptibility to injury is increased in cold stress because plasma volume drops and peripheral perfusion decreases. By showing that epinephrine elicited an arterial contraction that could be reversed by warming and withdrawal of the epinephrine, Prof. W.K. Keatinge (London Hospital Medical College) illustrated the possible basis for the oscillatory temperature changes of the finger exposed to cold. Cold injury to the nervous system was summarized by Prof. R.W. Gilliatt (National Hospital, London). Many structural changes following nerve cooling were characterized--intramyelin edema, axonal swelling, and increased collagen formation in perineural tissue. Severe pain on rewarming of cold-injured tissues and the lack of responsiveness of this pain to common analgesics were specifically mentioned.

The meeting was held at the Institute of Naval Medicine, Alverstoke, and included 33 UK and 21 US participants. Travel support for US attendees was provided in part by the Naval Medical Research and Development Command.

F.G. Hempel, M.D.
ONR, Washington, DC

UK ALVEY PROGRAM GETS GO-AHEAD

Patrick Jenkin, Secretary of State for Industry, has announced the UK government's decision to implement the Alvey Program--designed to keep the UK abreast of its US and Japanese semiconductor and computer competitors. The four key areas are software engineering, very large scale integration, man-machine interfaces, and fifth-generation, intelligent, knowledge-based systems. An investment of £350 million ($560 million) over a 5-year period is divided as follows: Department of Industry, £110 million; Ministry of Defence, £40 million; Department of Education and Science, £50 million; and participating industries, £150 million.

The key feature of the program will be collaboration among government, industry, and academia. Jenkin made it clear that steps will be taken to ensure that knowledge gained in the program "will not leak overseas to benefit the UK's competitors." This policy of secrecy is widely believed to be in retaliation for the US Department of Defense's restriction on knowledge gained in the very high speed integrated circuit program.

V. L. Voder

NEW TUNNELLING MICROSCOPE IN SWITZERLAND

Electron tunnelling through solid insulating films has been known since 1957 and is the basis of many semiconductor devices now in use. But it was not until early 1982 that controlled vacuum tunnelling was demonstrated in a configuration suitable for use in microscopy.

The controlled tunnelling was demonstrated by G. Binnig, H. Rohrer, C. Gerber, and E.Weibel at IBM in Zurich. The group has now used the same techniques to demonstrate a powerful new approach to surface microscopy. The tunnelling occurs because electrons have both wave-like and particle-like properties. In essence, the electrons can be represented as electron clouds extending slightly beyond the surfaces of solids. As a result, there is a finite probability that some of the electrons will tunnel through the vacuum. Sensitivity is such that a distance change of but one atom diameter causes a thousand-fold change in tunnelling current. In operation, the scanning tunnelling microscope exploits the strong dependence of the tunnelling current as a function of the separation between two solids. One solid is the surface under investigation, while the other is the sharp tip of a metal probe. A feedback system maintains a constant tunnelling current by positioning the probe 10 angstroms from the surface at all times. As the probe is laterally scanned, the feedback signal needed to maintain probe-substrate distance is a direct indication of local surface height. A vertical resolution of 0.1 angstroms is claimed; 6-angstrom horizontal resolution is achieved. (On precision translational measurement, see the article about the Delft Univ. of Technlogy elsewhere in this issue.)

The first application of the tunnelling microscope has been to study the silicon surface. A spectacular photograph that clearly depicts two rhomboid-shaped unit cells was produced. Hills and valleys within a unit cell are shown to have maximum vertical separations of 2.8 angstroms with 46-angstrom-long diagonals. Individual hills and bumps as close as 6-angstroms apart have never before been viewed.

M.N. Yoder

YUGOSLAVIAN RESEARCH VESSELS

Wayne V. Burt has furnished the following information to supplement his article on research vessel management in Furope (*ESN* 36-8:186-190 [1982]):

The Center for Marine Research of the Institute "Rudjer Boskovic" operates the 26-m *F/V Vilebitsa* out of their laboratory in Rovinge, Yugoslavia. The vessel is a rebuilt, wooden hulled, ex-mine sweeper with three nicely equipped laboratories housed in a new aluminum superstructure. It operates primarily in the northern Adriatic and concentrates on chemical and biological oceanography (especially eutrophication). The Institute for Oceanography and Fisheries operates the 27-m *F/V Bios*, a converted wooden ex-seiner with two modest laboratories. It also operates the 19-m *F/V Prevodnik*, an ex-trawler. Both vessels concentrate on fisheries research and associated food web studies.

F.A. Richards

CORRECTION

Dr. R.A. Hein (Catholic Univ. of America, Washington, DC) was the author of "IV Conference on Superconductivity in d- and f- Band Metals," *ESN* 36-10:246 (1982). Authorship was mistakenly attributed to B. Klein.

ONRL COSPONSORED CONFERENCES

ONR London can nominate two registration-free participants in the conferences it supports. Readers who are interested in such participation should contact the Chief Scientist, ONR London, as soon as possible.

International Symposium on Phase Relationships and Properties in Multicomponent Polymer Systems, Capri, Italy, 30 May - 3 June 1983.

International Conference on Ellipsometry and Other Optical Methods for Surface and Thin Film Analysis, Paris, 7-10 June 1983.

NATO ASI on Physics of Submicron Semiconductor Devices, Pisa, Italy, 10-23 July 1983.

Seventh International Conference on Vacuum Ultraviolet Radiation Physics, Jerusalem, Israel, 8-12 August 1983.

8th European Symposium on Fluorine Chemistry (ESFC-8), Jerusalem, Israel, 21-26 August 1983.

Sixth International Conference on Erosion by Liquid and Solid Impact (ELSI VI), Cambridge, UK, 4-8 September 1983.

International Conference on Electronic Properties of Two-Dimensional Systems, Oxford, UK, 5-9 September 1983.

1983 International Conference on Fourier Transform Spectroscopy, Durham, UK, 5-9 September 1983.

Second International Valencia Meeting on Bayesian Statistics, Valencia, Spain, 6-10 September 1983.

Microcircuit Engineering 83 Conference, Cambridge, UK, 26-29 September 1983.

16th European Conference on Laser Interaction With Matter, Imperial College, London, UK, 26-30 September 1983.

ONRL REPORTS

To request reports, check the boxes on the self-addressed mailer and return it to ONRL.

C-3-83: *The 3rd European Conference on Computer Aided Design for Small- and Medium-Size Industries*, by W.G. Magnuson, Jr. The conference emphasized applications of computer aided design in industries which have limited resources and are forced to innovate in order to compete. Specific topics included computer-aided design and manufacturing (CAD-CAM) user groups, mechanical engineering applications, CAD-CAM investment strategies, basic CAD techniques, CAD-CAM education and training, and applications in architecture and building design.

C-4-83: *The 12th International Quantum Electronics Conference*, by P.D. Drummond. The 12th International Quantum Electronics Conference was held in Munich, Germany, from 22 through 25 June 1982. This report describes presentations on dynamical nonlinearities, quantum optics, bistability, laser spectroscopy, and theory.

C-5-83: *The 14th International Symposium on Applied Military Psychology*, by N.A. Bond, Jr. The symposium concentrated on five themes: stress research and management, administrative and management issues, women in the armed forces, information processing, and selection and prediction.

C-6-83: *The 29th International Field Emission Symposium*, by T.E. Feuchtwang. The 29th Annual Field Emission Symposium was held at the Chalmers Technical Univ. in Göteborg, Sweden, from 9 through 13 August 1982. The topics exciting most interest were liquid metal ion sources and pulsed laser atom-probes. There were considerably fewer papers on electron emission than on ion emission. About half the papers were concerned with specific applications.

C-7-83: *NATO/AGARD Symposium on Software for Avionics*, by D. Weiss. The symposium was concerned with requirements, design, development, verification, and validation of avionics software. A few papers concerned research results and future technology, but most dealt with the practical aspects of software development.

R-2-83: *Statistics, Operations Research, and Management Science in Europe--1981: Summary Report*, by D.R. Barr. This report discusses the state of European research in statistics., operations research, and management science. The report analyzes trends in research and examines conditions that affect work in British and Continental universities.

ONRL REPORTS (CONT'D)

R-3-83: *Free Electron Laser Research in Europe*, by J.R. Neighbours. This report describes the activity in free electron laser research in France, Israel, Italy, and the United Kingdom. In addition, the report lists key scientists and their recent works.

R-4-83: *Annular Plasmas for Intense X-radiation Diodes: Assessment Report*, by D. Mosher. A new technique for annular plasma production developed at the Ecole Polytechnique, Palaiseau, France, appeared to solve many of the source creation problems currently encountered in US Department of Defense programs.

EUROPEAN VISITORS TO THE US SUPPORTED BY ONR LONDON

Visitor	Affiliation	Organization to be Visited
Mr. P.Y. Bell	Project Officer, "Submarine Escape" Admiralty Marine Technical Establishment Physiology Laboratory Alverstoke, Gosport, Hants. PO12 2DU	Naval Submarine Research Lab New London, Groton, CT (7-10 June 1983) Naval Medical Research Inst. NNMC, Bethesda, MD (13-18 June 1983) Underwater Physiology Symposium [illegible], Quebec, Canada ([illegible] June 1983)
Prof. H.C.A. Dale	Ergonomics Research Group Univ. of Hull 26 Newland Park Hull HU5 2DW	Navy Personnel Research & Development Center, San Diego, CA (27-29 June 1983) Aviation Psychology Lab Ohio State Univ. (4-6 July 1983) Wright-Patterson AFB (4-6 July 1983)
Dr. R.J.A.W. Hosman	Department of Aerospace Engineering Delft Univ. P.O. Box 5058 2600GB Delft The Netherlands	Navy Personnel Research & Development Center, San Diego, CA NASA-AMES Laboratory Sunnyvale, CA (Both May-June 1983)
Dr. R. Huber	Hochschule der Bundeswehr München Neubiberg, FRG	CNA, Alexandria, VA NPG School, Monterey, CA (June 1983)
Dr. S. Jakobsson	Museum of Natural History P.O. Box 5320 Reykjavik, Iceland	ONR, Arlington, VA. (10-19 May 1983) US Geological Survey Menlo Park, CA (18 May-10 June 1983)

EUROPEAN VISITORS (CONT'D)

Visitor	Affiliation	Organization to be Visited
Prof. G. Kanji	Department of Mathematics, Statistics, and Operations Research Pond Street Sheffield S1 1WB	ONR, Arlington, VA (9 June 1983) George Washington Univ. Washington, DC (10 June 1983) Iowa State Univ. Ames, IA (13-15 June 1983)
Mr. C.E.C. Wood	General Electric Company, Ltd. Hirst Research Centre East Lane Wembley Middlesex HA9 7PP	NRL, ONR (24-25 May 1983) Cornell Univ. (27 May - 18 June 1983) Univ. of Vermont (20-24 June 1983)


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